DRAFT

Profiler EMP-400

User's Manual

The World Leader in Subsurface Imaging™

Geophysical Survey Systems, Inc.

Tel 603.893.1109 • Fax 603.889.3984
sales@geophysical.com
www.geophysical.com

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Warning: Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment or residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the introduction manual, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.

Shielded cables must be used with this unit to ensure compliance with the Class B FCC limits.

Canadian Emissions Requirements

This Class B digital apparatus complies with Canadian ICES-003.

Cet appareil numerique de la classe A est conforme a la norme NMB-003 du Canada.

Declaration of CE Conformance

The Profiler EMP-400 has been certified to meet the requirements of the following European standards:

EN61326:1997, A1:1998, A2:2001

Table Of Contents

Chapter 1: Introduction 1
1.1 Unpacking Your System 1
1.2 General Description 2
1.3 The Profiler EMP-400 3
1.4 The Profiler Removable Battery Pack 4
1.5 TDS Recon-400 PDA 6
1.6 TDS Recon-400 Power Boot Module and AA Power Boot Module 8
1.7 PDA Mount and Low Carry Handle 10
1.8 Remote RF Key Fob 12

Chapter 2: Profiler EMP-400 Setup 13
2.1 Starting the EMP-400 13
2.2 User Access to TDS Recon-400 PDA Time, Date, Power and Battery Settings . 14
2.3 Recall Setup 18
2.4 Check System Diagnostics Parameters 19
2.5 Check System Parameters 29
2.6 System Calibrations 34
2.7 Select Grid Configuration (Grid Config.) 41
2.8 Review Parameters 45
2.9 Save Setup 48

Chapter 3: Collecting Data 49
3.1 Set Data Display Parameters 49
3.2 Data Collection 50
3.3 Data Review 56
3.4 Shutting Down the System 61

Chapter 4: Transferring, Converting and Exporting EMP-400 Data 63
4.1 Transferring Data 63
4.2 Transferring Data Using ActiveSync 64
4.3 Transferring Data Using File Transfer Utility 69
4.4 Converting Files in MagMap2000 70
4.5: Working with *.EMI and GPS Files in MagMap2000 73

Appendix A: Understanding GPS And WAAS 83

Appendix B: Example of GGA Data String 87

Appendix C: Conducting a Survey 89

Appendix D: Useful References 95

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Chapter 1: Introduction

This user manual has been written for both the novice and the experienced user of electromagnetic induction (EM) instruments. This manual is provided as an operational reference tool. It is highly recommended that the user read the entire manual, regardless of your level of experience with electromagnetic induction theory, applications, and other electromagnetic induction instrumentation. Appendix A contains useful information about the WAAS GPS system supplied with the Profiler. Appendix B is a summary of the basic steps in conducting an EM survey. For additional information on EM theory and applications please review the list of references, which can be found in Appendix C.

1.1 Unpacking Your System

Thank you for purchasing a GSSI Profiler EMP-400 electromagnetic induction (EMI) instrument (hereinafter referred to as the EMP-400). A packing list was included with your shipment, which identifies all of the items that are in your order. If you find that an item is missing, or damaged during shipment, please call, or fax your sales representative immediately so that GSSI can take steps to correct the problem.

Your EMP-400 system (Standard Configuration) includes the following items:

1 – EMP-400 Transit case (large). This includes:

1 – Profiler EMP-400 digital electromagnetic induction instrument
1 – Low carry handle and mounting clamps
1 – Hip height padded shoulder carrying strap and mounting straps
1 – EMP-400/Recon-400 PDA mounting bracket and clamp

1 – EMP-400 Transit case (small). This includes:

1 – TDS Recon PDA with integrated Bluetooth service and Holux™ WAAS GPS module
1 – AC rechargeable power boot module for Recon-400 PDA
1 – AA battery power module for Recon-400 PDA
1 –120 V AC re-charger for Recon-400 power boot module
(see PDA manual for Input/Output specifications for International AC charger)
1 – Battery charger for EMP-400 Li-Ion battery
1 – AC power supply for Li-Ion battery charger
1 - AC power cord for AC battery charger power supply
2 – Re-chargeable Li-Ion batteries for EMP-400
1 – AA backup battery pack for EMP-400
1 – RF remote control key fob and lanyard
1 – PDA stylus pen and lanyard
1 – USB data transfer cable
1 – Spare stylus pen
1 – Package of PDA screen protectors (10 count)
1 – Recon-400 hand strap

1 **– User's Manual – PLEASE READ**
1 – User's CD containing your unit's backup calibration files. The system calibration files are identified by the system serial number. Geometrics MagMap2000 software and a *.PDF copy of the User's Manual, the Profiler File Transfer Utility Program and the GEOMETRICS MagMap 2000 manual
1 – TDS Recon Getting Started Guide
1 – TDS Recon Companion CD
1 – OEM copy of Microsoft® Windows Mobile™ 2003 software for Pocket PC.

1.2 General Description

Electromagnetic induction instruments are used for many different types of geologic, engineering and environmental applications. These include shallow soils mapping, soil-salinity mapping, ground water investigations, the detection, and delineation of waste pits and associated subsurface contaminants from acids, salts or volatile organic contaminants (VOC's). They have also been used extensively for the detection of conductive geologic media such as clays and ferrous mineral deposits, as well as the detection of resistive geologic media such as sand and gravel deposits. In addition, the systems are used for near-surface archaeological investigations for the purpose of detecting buried structures, such as ancient building foundations, as well as for the detection of buried conductive metallic objects such as drums, tanks, large metallic utilities and other non-descript metallic objects.

The Profiler EMP-400 is a portable, digital multi-frequency electromagnetic induction sensor. The user can collect from one (1) to three (3) frequencies simultaneously. The system bandwidth extends from 1 kHz to 16 kHz in 1 kHz steps. The system's primary data output is the In-Phase and Quadrature components of the mutual coupling field ratio (Q) of the primary transmitted field to the induced secondary field in parts per million (PPM) at all frequencies. The system has also been calibrated to provide the apparent conductivity (σ_A) at **15 kHz**. In addition, the system will output the magnetic susceptibility at ?kHz The magnitude of the In-Phase and Quadrature components of the induced secondary field, as well as the apparent conductivity and the magnetic susceptibility are collected and stored for each reading along with a time stamp and user supplied survey grid information. GPS data, in the form of a NMEA 0183 GGA string is also recorded if the WAAS GPS is enabled, or if an external GPS system is interfaced with the PDA via PDA RS-232 serial port.

The system sensor electronics are controlled via a wireless Bluetooth™ communications interface. The system user interface and data storage are incorporated into a TDS RECON-400 Personal Digital Assistant (PDA) provided with the system. The instrument weighs 10 lbs. The system coil configuration is Horizontal Co-Planar (HCP). The inter coil spacing is 1.219 meters (4 feet). Data can be collected in both the vertical (VDM) and horizontal (HDM) dipole modes. The instrument is powered by a re-chargeable Li-Ion battery pack, or by eight (8) AA batteries. The PDA is powered by an AC rechargeable power pack or optional AA battery power pack. The PDA is configured with an integrated 12-channel WAAS (Wide Area Augmentation System) GPS that enables the user to collect geo-referenced data. The EMP-400 system and the TDS Recon-400 PDA are environmentally sealed and self contained and have no user serviceable parts. The major system components are the EMP-400, the EMP-400 battery pack and the TDS Recon-400 PDA. These are illustrated in Figures 1 through 8.

1.3 The Profiler EMP-400

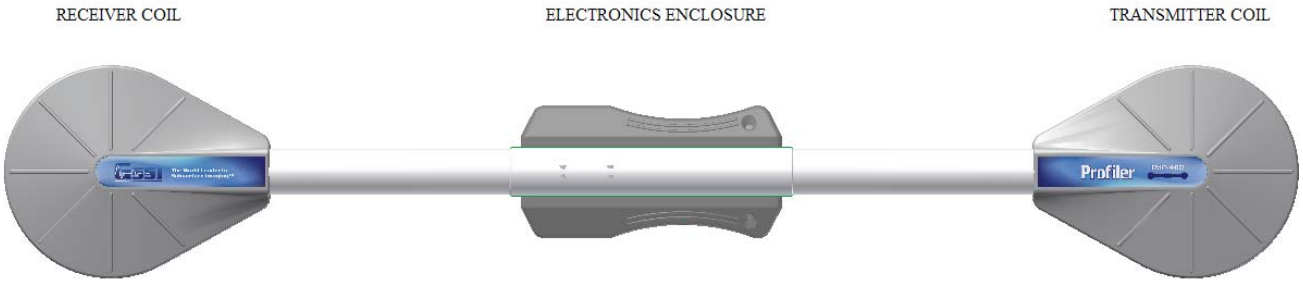


Figure 1: EMP-400 top view.

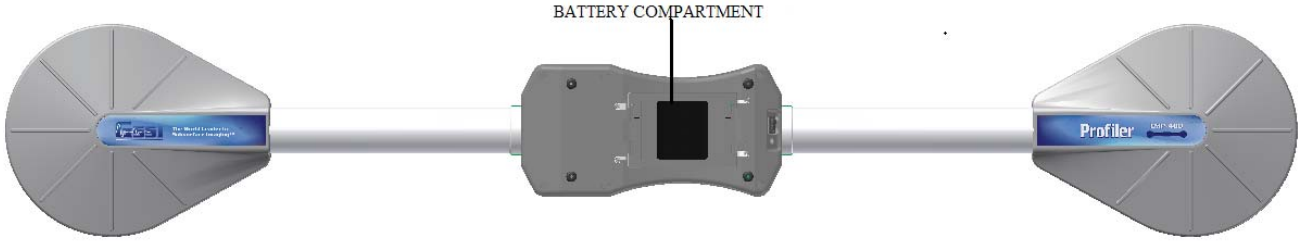


Figure 2: EMP-400 bottom view.

The EMP-400 has no external connectors or I/O ports. An expanded view of the EMP-400 electronics enclosure is illustrated in Figures 3 and 4.

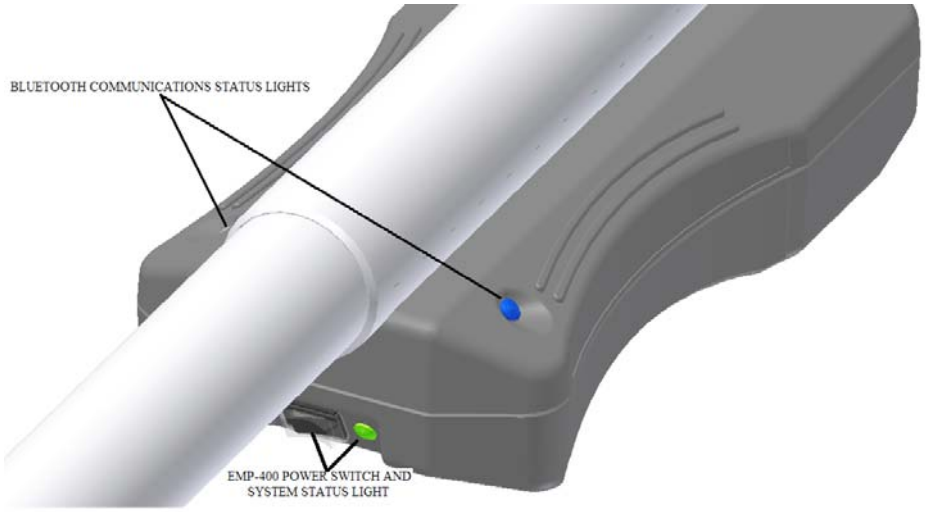


Figure 3: EMP-400 top view showing the location of the system power switch, Bluetooth communications status and system status lights.

The EMP-400 is powered by re-chargeable Li-Ion batteries. The batteries are accessible via the removable battery pack located on the bottom of the electronics assembly (Figure 4).

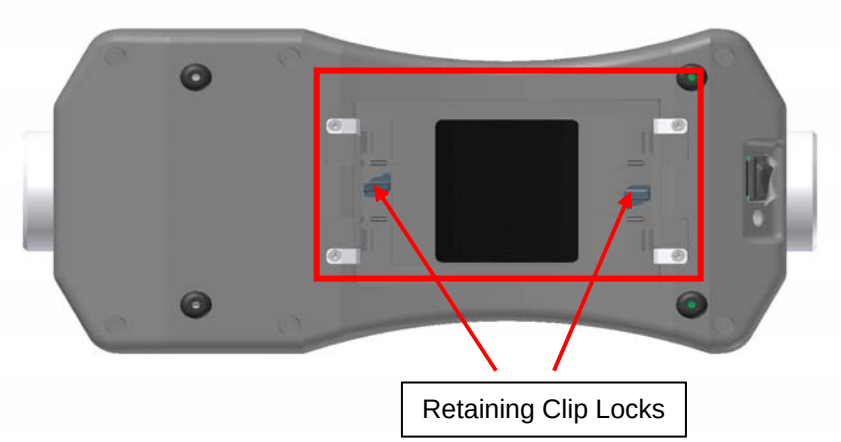


Figure 4: EMP-400 Electronics Assembly bottom view showing the location of removable battery pack outlined in red.

1.4 The Profiler Removable Battery Pack

The EMP-400 battery pack is removed from the unit by *gently* pulling the removable battery pack retaining springs towards each other (towards the center of the battery pack) until they snap out from beneath the four (4) retaining clips screwed into the bottom of the EMP-400 electronics assembly (Figure 4 above and Figure 7 below). The locks on the battery pack retaining clips prevent the clips from accidentally opening when the EMP-400 base brushes against tall grass, field stubble, or other near-surface objects. Engage the locks by turning the clip locks 90 degrees clockwise. The operator can use the reverse end of the PDA stylus as a tool to turn the locking tabs.

- The removable battery pack accepts the 10.8 VDC Li Ion batteries provided with your system. Operation time of the Li Ion battery on a single charge is ~ 9 hours minimum when operating at one measurement per second at ambient temperature of +15o C to +35o C. Operation time of the Li Ion battery on a single charge is 18 hours when operating at one measurement per second at ambient temperature of +25o C. Life expectancy is 300 charge/discharge cycles. The discharge temperature limits are -10o C to +50o C. The storage temperature limits are -20o C to +60o C.
- Fully charged battery status is indicated by five (5) rectangular black squares located on the liquid crystal battery charge gauge on the end of the battery opposite the five (5) battery contact slots.
- The EMP-400 Li Ion batteries should be placed in the Li Ion charger when the battery charge gauge reaches one (preferably two) squares. The time required to recharge an EMP-400 battery is three and a quarter hours for a fully discharged battery.
- The removable battery pack also accepts eight (8) AA 2500 or 3500 mAh NiMH batteries for backup system power when the primary Li Ion batteries are recharging. The operating time for AA batteries at one measurement per second at an ambient temperature of +25oC without the WAAS GPS enabled is 20 hours for rechargeable 2500 mAH batteries.

The rechargeable Li Ion battery pack and AA battery packs are illustrated in Figures 5 and 6.

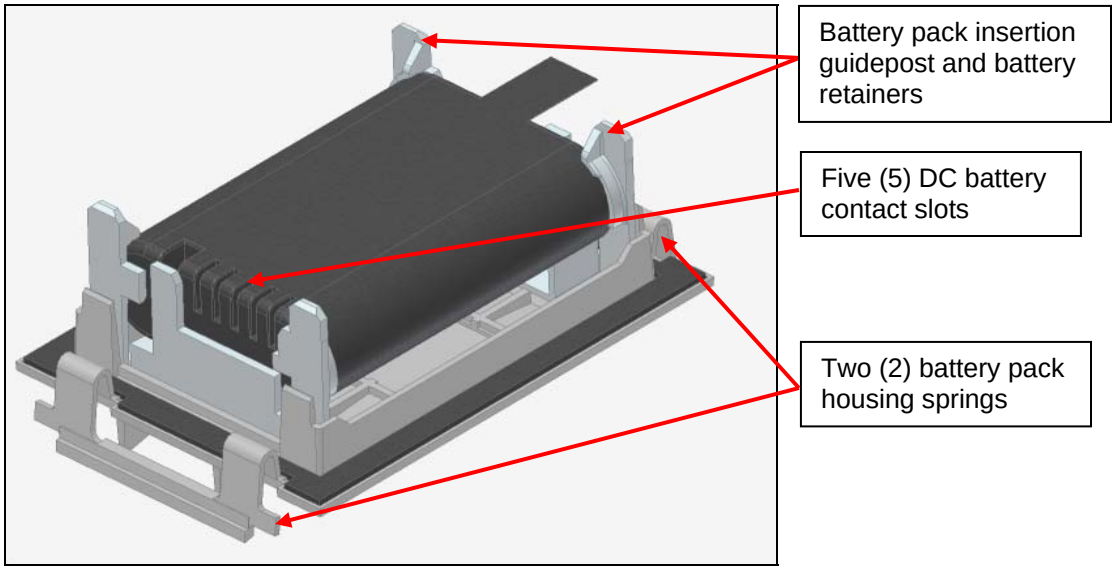

Battery pack insertion guidepost and battery retainers
Five (5) DC battery contact slots
Two (2) battery pack housing springs

Figure 5: Re-chargeable Li-Ion battery pack and removable battery pack housing.

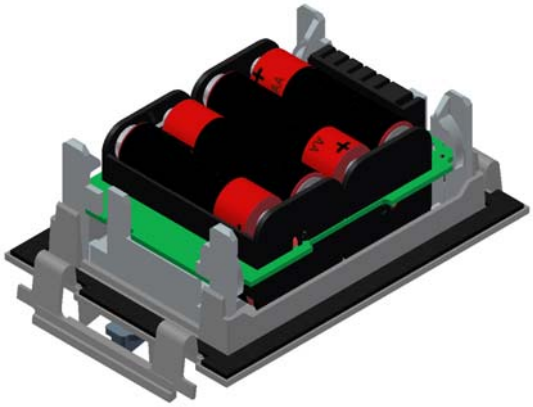


Figure 6: AA battery pack and removable battery pack housing.

Installing the EMP-400 Batteries

The Li Ion battery or AA battery pack is inserted into the EMP-400 battery pack by inserting the battery and gently pinching the battery pack housing springs back until the battery (or AA battery pack) snaps into place. GSSI recommends that the user insert a **fully** charged Li Ion or AA battery pack into the EMP-400 battery pack housing prior to data collection.

The entire EMP-400 battery pack is then inverted and then inserted into the EMP-400 electronics enclosure. The user should gently squeeze the battery pack retaining clips and then insert the battery pack into the EMP-400 electronics assembly using the insertion guideposts.

The battery must be installed into the removable battery pack correctly. The five (5) DC contact slots on the Li Ion or AA battery pack should align with the five (5) DC battery terminals located on the EMP-400 electronics assembly board inside the removable battery pack enclosure. The battery should be inserted so that the five (5) battery contact slots are facing UP (Figures 5 and 6).

Press gently on the top of the battery pack until the retaining springs click into place (Figure 7). Be certain the clip locks have been rotated counter-clockwise (unlocked) before pressing on the retaining springs. The pack can be removed by gently pinching the battery pack housing springs until the springs un-snap from beneath the four white battery pack housing clips (Figure 7).

The system can now be turned ON by depressing the EMP-400 power button located at the front of the EMP-400 electronics assembly (Figure 3). The **Green** power LED should illuminate, and then the **Blue** Bluetooth™ communications lights will illuminate. This indicates that the EMP-400 is receiving power from the battery pack and that the voltage level of the batteries is sufficient to operate the system and that the Bluetooth communications link is enabled.

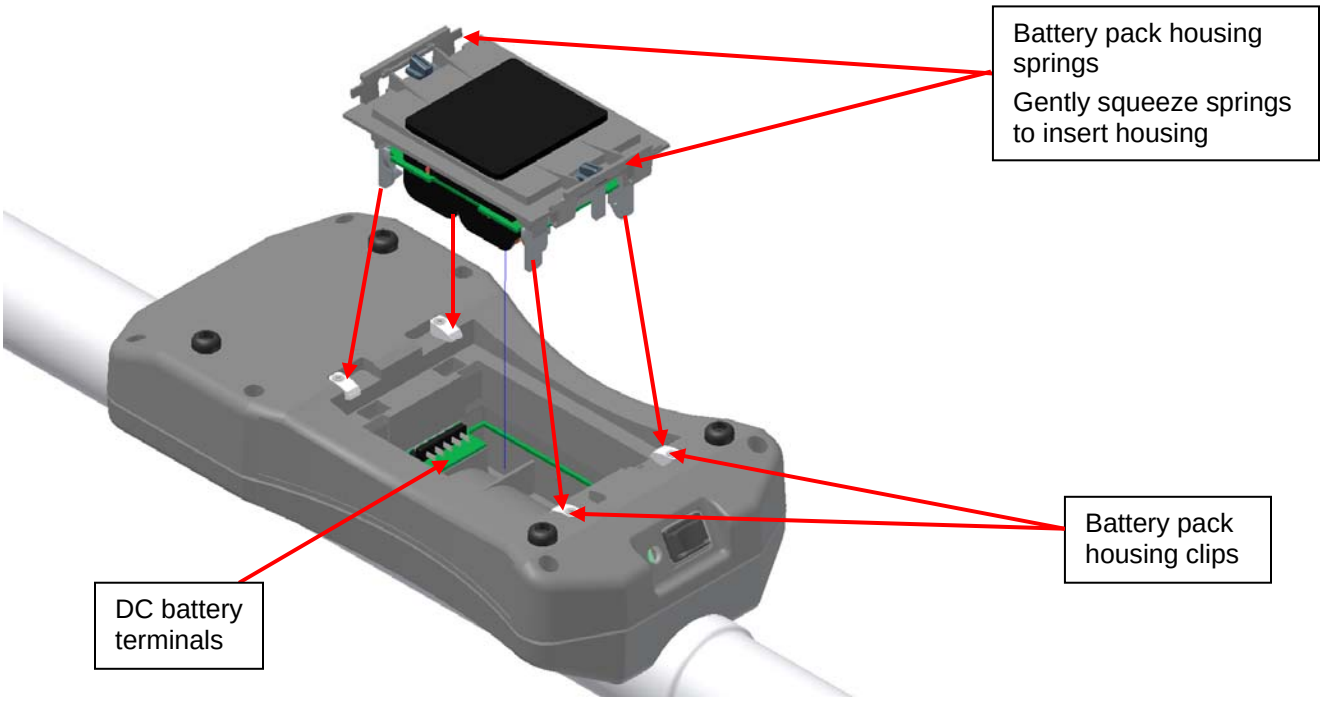

Battery pack housing springs
Gently squeeze springs to insert housing
Battery pack housing clips
DC battery terminals

Figure 7: Inserting the removable battery pack into the EMP-400 electronics.

1.5 TDS Recon-400 PDA

The Tripod Data Systems (TDS) Recon-400 is a portable, field rugged PDA. It is the platform for the Graphic User Interface (GUI) and data storage of the EMP-400.

Caution: GSSI assumes no responsibility for Profiler interface operating difficulties if the user installs any additional third-party software in the Profiler PDA, or reconfigures the PDA Bluetooth™ connection for operation with any other third-party devices.

Specifications

- The Recon-400 incorporates an Intel PXA255 X Scale CPU running at 400 MHz.
- It is configured with 64 MB high-speed SDRAM and 256 MB of non-volatile storage.
- The system display is a 240 X 320 pixel (1/4 VGA) color TFT display with LED front light.

- It is configured with integrated Bluetooth® communications and a 12-channel HOLUX™ WAAS GPS receiver.
- Available Profiler PDA user storage memory is 248 MB. The system is capable of storing EMP-400 readings in Continuous mode and 500,000 readings in the Discrete mode. The maximum number of readings in each mode is a function of the grid dimensions and reading (step) and line spacing. The system will issue a user warning if your grid parameters exceed the PDA data storage memory limit.
- The PDA weighs 17 ounces and has an operating temperature range of -30° to +60° C. Storage temperature limits are -40 to +70° C. Battery life is 500 charge/discharge cycles (typical) if battery is stored at least partially charged between 0° to +35° C.
- The system meets MIL-STD-810F standards for humidity, water (accidental immersion), drop, vibration, humidity, and altitude. It has an IP67 rating and is impervious to water and dust.
- A rechargeable 3800 mAh NiMH DC power boot module or an optional AA battery power boot module supplies power to the unit.
- Input/Output and power ports include a D-shell RS-232 serial port, a USB data port, and an AC charging port for the AC power boot module.
- The Operating System software is Windows™ Mobile 5.0.

Figure 8: TDS Recon-400 Ver 1069 keypad layout.

TDS Recon-400 PDA Connectors

The TDS Recon-400 has three (3) primary connectors: One (1) AC battery charger connector, One (1) D-Shell RS-232 serial port connector and one (1) USB data port (Figure 9).

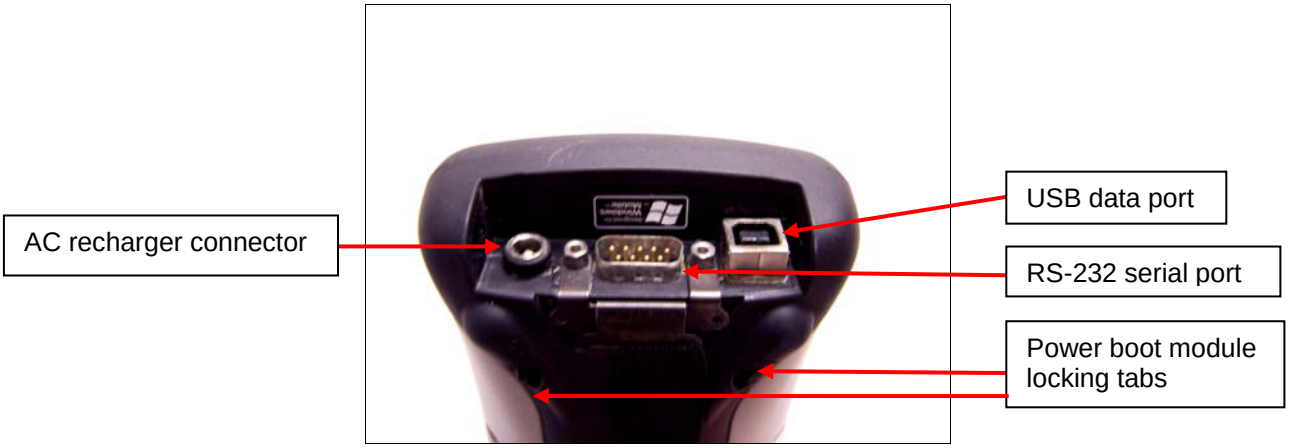


Figure 9: TDS Recon-400 connectors.

1.6 TDS Recon-400 Power Boot Module and AA Power Boot Module

Your Recon-400 is supplied with two (2) interchangeable DC power supplies (Figures 10 and 11). The system is configured with the AC rechargeable power boot module installed.

- The power boot module(s) can be removed from the PDA by turning the module locking tabs to the unlocked position.
- Your Recon-400 is supplied with a screen stylus that has a screwdriver tool opposite the stylus end. This tool is used to lock and unlock the power boot modules and the protective cap for the WAAS GPS card, and to secure the locks on the removable battery pack. The modules can be secured by returning the locking tabs to the locked position. The location of the locking tabs is illustrated in Figure 11.
- The AA power boot module accepts two (2) AA batteries. Under normal operating conditions and with the appropriate batteries, the AA power boot module will operate for approximately 2-3 hours. When using the WAAS GPS, system-operating time drops to 1.5 hours.

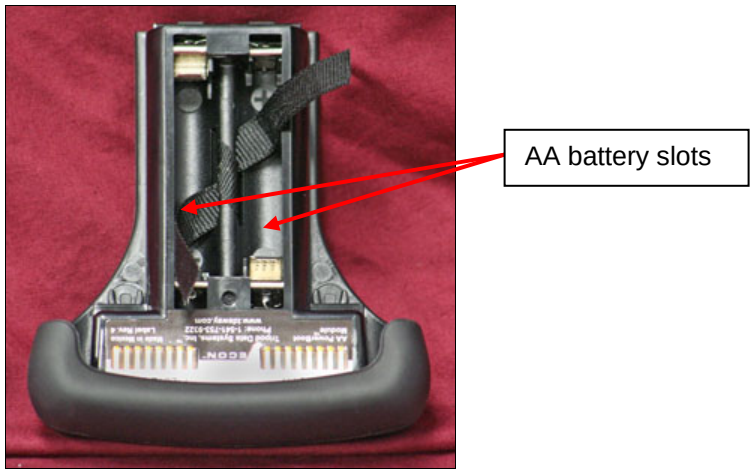


Figure 10: PDA AA power boot module (front).

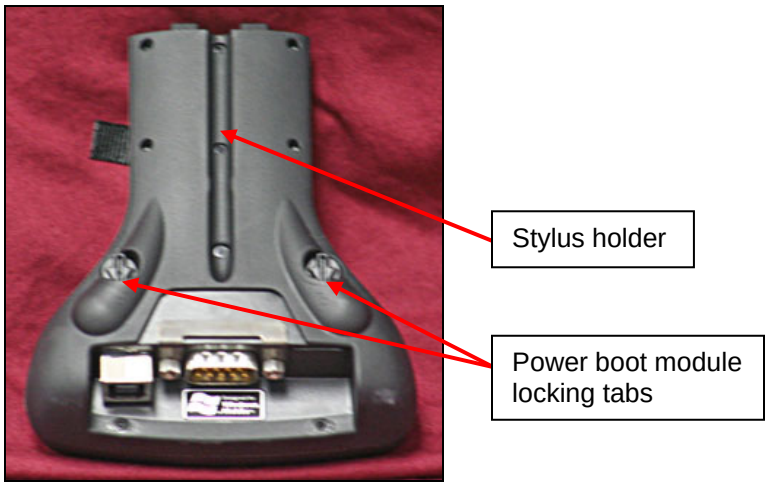


Figure 11: PDA AA power boot module (back).

- The AA power boot module is provided as a BACKUP to the standard AC power boot module. GSSI does not recommended that the AA power boot module be used as the primary power source. Using the AA power boot module as the primary power supply will reduce PDA operating duration. The AA power boot module is intended for use while the AC power boot module is recharging. The AC power boot module requires approximately 1-2 hours to fully recharge.

Note: GSSI recommends the user obtain rechargeable 2500 mAh batteries for use in the AA power boot module. These batteries can be found at most electronics and/or hardware supply store or any commercial retailer that sells standard AA batteries. The AA power boot module endurance times given above are for 2500 mAh rechargeable batteries.

Caution: PDA operating times may be reduced if the user installs standard AA batteries in the AA power boot module.

1.7 PDA Mount and Low Carry Handle

PDA Mount

Your EMP-400 is supplied with both a shoulder strap, for hip height deployment, and a low carry handle for near-surface deployment. The system is supplied with two (2) Velcro cinch straps that are secured to the EMP-400 tube-body by adjusting the strap tension. The straps have attached plastic clips, allowing the user to clip the EMP-400 carrying strap to the cinch straps. The Velcro cinch straps and the shoulder-carrying strap are adjustable. The EMP-400 shoulder strap should be adjusted so that the EMP-400 is approximately 1 meter from the ground surface or approximately hip height during data collection.

The PDA mount (Figure 12) attaches to the main tube of the EMP-400 with a screw-clamp. The PDA is designed to slip into the black plastic bracket on the PDA mount. If inserted properly, the PDA should click into place. The orientation of the PDA can be adjusted for easy viewing by the operator. The PDA mount incorporates a lockable ball joint and armature adjustment that allows the user to adjust the pitch and the angle of the PDA screen. When the desired pitch and angle adjustment has been made, use the ball joint locking lever to lock the PDA into position by moving the lever from the horizontal to vertical position. *Do **not** force the ball joint armature without unlocking the ball joint. This will damage the ball joint.*

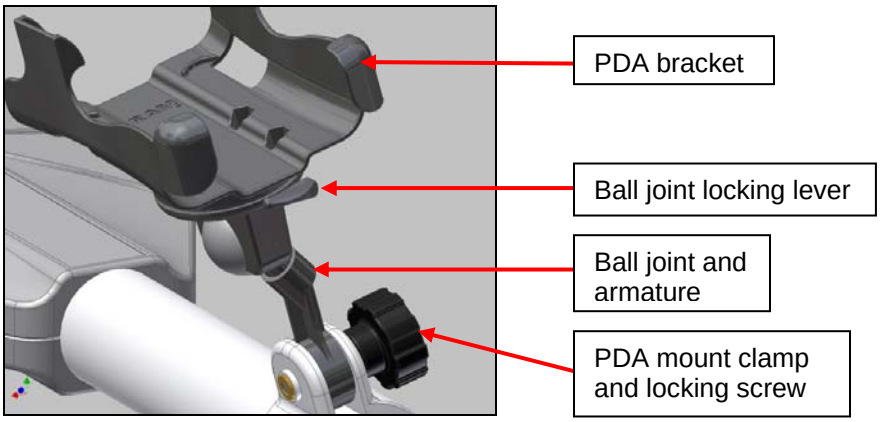


Figure 12: PDA adjustable mounting bracket and clamp.

Note: It is not recommended that the PDA clamp be attached to the EMP-400 when the low carry handle is used. The PDA display will not be easily visible to the user. The PDA mount and low carry handle clamp screws should be screwed into the clamp so that the threaded brass insert is on the opposite side of the clamp from the screw head (Figure 12).

Figure 13 illustrates the PDA mount with the PDA inserted and the shoulder carry strap attached to the EMP-400 tube. The PDA mount clamp should be attached to the EMP-400 tube so that the clamp butts up against the tube section to which the electronics enclosure is attached. This position provides better balance to the instrument when using the shoulder strap.

Figure 13: EMP-400 with the PDA mount and PDA installed.

Low Carry Handle

The EMP-400 can be deployed with a low carry handle. The handle allows the user to carry the EMP-400 in closer proximity to the ground surface. In general, the closer the proximity of the EMP-400 to the ground surface, the greater the In-Phase response. The handle enables the user to switch from VDM mode the HDM mode simply by loosening the handle screws and rotating the instrument 90°. The low carry handle is attached to the EMP-400 tube by attaching the two screw-clamps provided with the handle. As indicated above, the screws should be inserted into the clamps so that the brass threaded insert is opposite the screw head. The low carry handle, clamps, and clamp screws are illustrated in Figure 14.

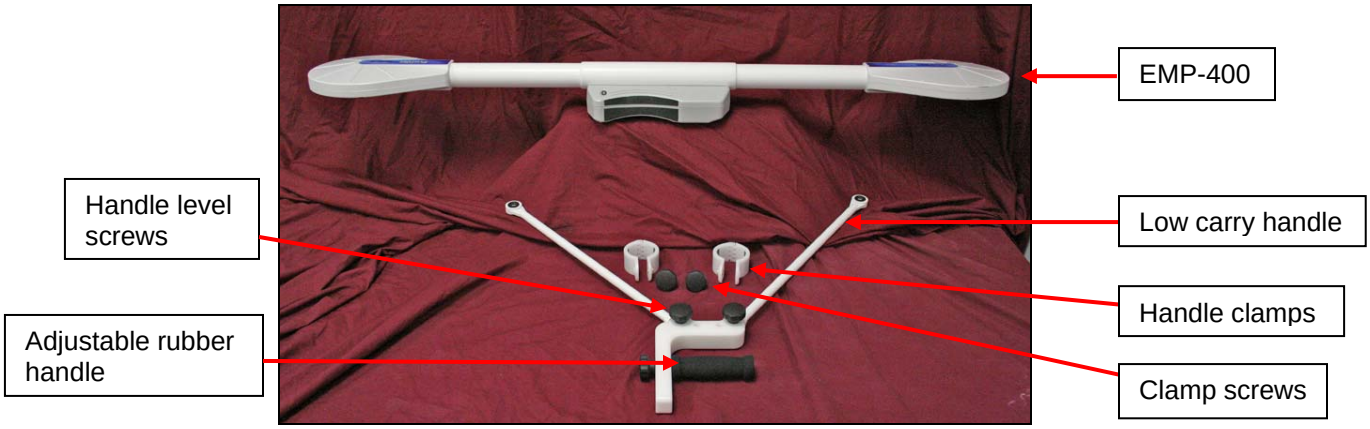


Figure 14: EMP-400, low carry handle and two (2) screw clamps.

Figure 15: Attaching clamps for low carry handle.

Attaching and Adjusting Low Carry Handle

Position a clamp and the handle tube as shown in Figure 15 and insert the clamp screw through the blind side of the handle clamp, i.e., the side of the clamp opposite the threaded brass insert, and through the rubber bushings at the bottom of the carry handle.

Slowly screw the threaded clamp screw through the clamp and handle until the screw is tight.

Repeat this process with the other handle clamp.

- The height of the handle can be adjusted by loosening the handle clamps and sliding them towards (lower) or away (higher) from the EMP-400 coils.
- The user can also adjust the handle height by removing the rubber handle screw and repositioning the rubber handle in one of the three (3) pre-drilled holes in the carry handle.
- The level of the EMP-400 can be adjusted by loosening the two handle level screws beneath the handle and adjusting the handle until the handle and EMP-400 are level. The handle level can be checked by placing the EMP-400 on a flat surface and the handle screws adjusted as necessary.
- The recommended deployment height when using the low carry handle is 8 inches (20 cm) from the ground surface.

Note: To obtain reasonable apparent conductivity (σ_a) values the system should be deployed with the low carry handle and operated at a transmit frequency of 15 kHz. This is discussed in detail in Chapter 2 Section 2.4 System Calibration.

1.8 Remote RF Key Fob

The EMP-400 is supplied with a remote RF key fob for remote Start/Stop of EMP-400 during data acquisition and for placing fiducial marks in data files collected in the Continuous mode (Figure 16).

Figure 16: RF key fob.

Chapter 2: Profiler EMP-400 Setup

2.1 Starting the EMP-400

1. Prior to starting system setup and data acquisition, insert a fully charged Profiler Li-ION battery into the removable battery pack (see Section 1.4: Profiler Removable Battery Pack).
2. Turn **On** the EMP-400.

- The **Green** power status light next to the EMP-400 power switch will illuminate.
- The **Blue** Bluetooth communication status lights will also illuminate.
- When the EMP-400 Li Ion battery reaches a power low condition, the **Green** power status light will begin to blink.

3. Turn **On** the PDA by depressing the PDA Power ON/OFF button.
4. After PDA power up, the RECON-400 will display the Profiler splash screen will appear (Figure 17).

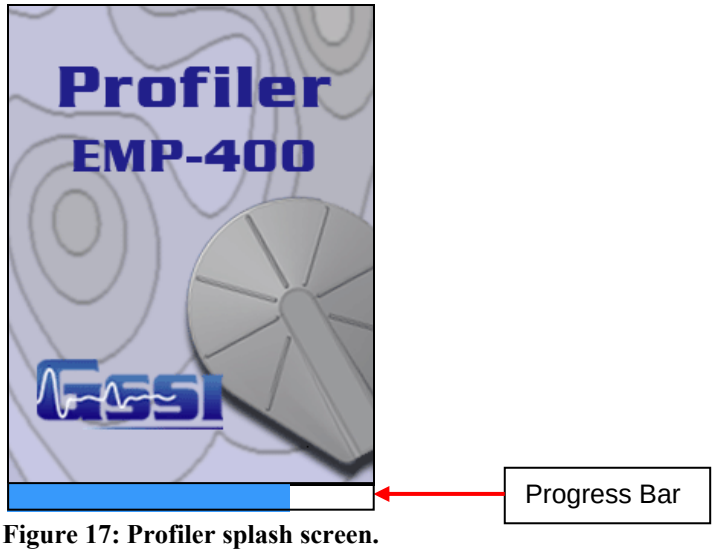


Figure 17: Profiler splash screen.

5. Upon initialization of the EMP-400 user interface, the Profiler splash screen will appear (Figure 17). Beneath the splash screen a **Blue** progress bar will appear.

- It will take the PDA approximately 30-40 seconds to load the Profiler software and establish communications with the EMP-400.
- When initialization of PDA/EMP-400 communications is complete, the progress bar and splash screen will disappear.

6. The PDA will then display the EMP-400 Main menu (Figure 18). At the bottom of the screen, the PDA battery charge status, the speaker status (On/Off) and the current system time are displayed.

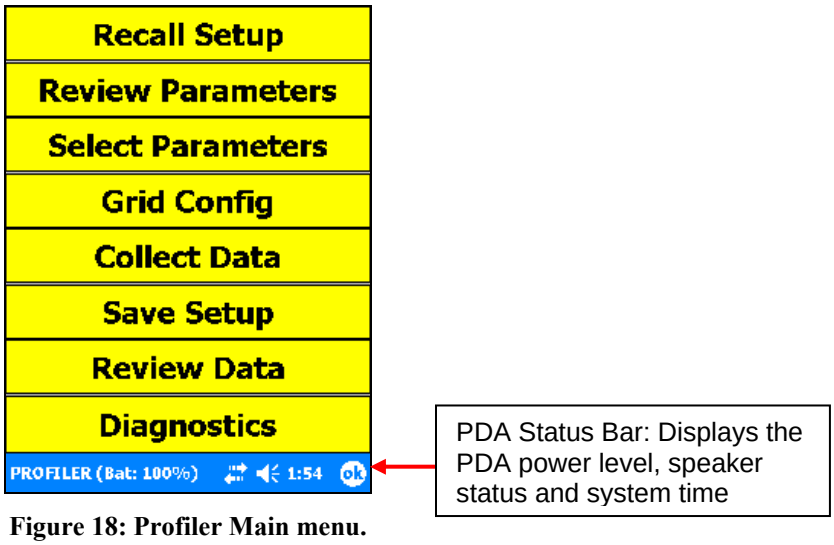


Figure 18: Profiler Main menu.

GSSI recommends that the operator utilize the PDA stylus to make all touch screen system parameters selections. Nails, pens, pencils, finger nails etc. will damage the touch screen. The PDA is supplied with screen protectors. GSSI strongly urges the user to use these and replace them when necessary.

2.2 User Access to TDS Recon-400 PDA Time, Date, Power and Battery Settings

The user should place the PDA on charger upon unpacking the instrument. The Windows 5.0 operating system is stored in non-volatile memory, however, GSSI recommends placing the PDA on the charger for several hours after every survey, or when that PDA battery gas gauge reads 25% or less.

The Recon-400 Windows 5.0 operating system has on board power management and a battery gas gauge that is visible to the user during system operation. The Profiler Graphic User Interface (GUI) has been modified in order to prevent inadvertent damage, or system operating problems which can be caused by user modification to the PDA factory default settings for the power, battery and display settings. The Profiler graphic user interface operates in a mode that prevents the user from accessing most of the Windows 5.0 operating system controls upon PDA start up. These settings have been configured at the factory and should not be changed by the user.

- This operating mode **does** allow the user to set the correct 'local' system time and date.
- This operating mode **does** allow the user to modify the Windows SYSTEM power options for the display backlight settings for the 'On Battery Power' options, and the 'On Eternal Power' options. The user can also modify the system display screen brightness for both 'On Battery Power' and 'On External Power' options.
- The system sound level and System Error or operation 'courtesy' notification parameters have been set at the factory. The user should not modify these settings.
- When using the AC rechargeable power boot module, under normal operating conditions, the Recon-400 should operate for up to 4.5 hours. When using the WAAS GPS system, operating time drops to ~2.5 hours.

- Operating the PDA with less than 25% battery power may result in intermittent loss of Bluetooth communication and potential loss of data. GSSI recommends that the PDA power boot module be recharged when the power level reaches 25%.

These Windows SYSTEM display settings have been set at the factory for maximum brightness on both External (AC) and battery power. The Windows SYSTEM backlight settings have been set to turn on the backlight when a keypad button is pressed or the touch screen is tapped. The Windows SYSTEM backlight settings have been set to prevent the backlight from being turned off. The Windows SYSTEM advanced power settings have been preset at the factory. The Windows SYSTEM 'On Battery Power' device shut down and 'On External Power' device shut down parameters have been turned **Off** at the factory to prevent inadvertent shutdown of the system and\or display and to prevent interruptions of Bluetooth communications during a survey. GSSI recommends that these settings NOT be modified by the user. Changing these settings may lead to unpredictable display operation during data collection. Changing these settings may also lead to system shutdown during Profiler system operation or data collection.

Caution: The Profiler Li ION batteries, if used incorrectly for a period of time, can develop 'memory effect' i.e. they will not hold a full charge and will not operate at their full capacity. They can acquire 'memory effect' if the user runs the Profiler PDA and does not discharge the battery completely, then recharges it. If the system is operated in this manner several times, the battery will lose the capacity to hold a full charge**.** The battery can be "re-programmed" by running the PDA until the battery is ***completely*** discharged. It should then be placed on the charger for 12 hours. The PDA should **NOT** be placed on the charger for any longer than a 12 hour period. Charging the PDA Power Boot Module for longer than 12 hours will damage the battery, and could create a potential fire hazard. This process should be repeated for three or four cycles, i.e. completely discharge the battery and then recharge for twelve (12) hours.

To Modify The PDA System Time and Date

1. To modify the System Date, Time or Power Parameters, turn on the Profiler and the PDA as per the directions outlined in Section 2.1.
2. From the Main menu select **OK** (Figure 18). This will switch the interface to the program Confirm Exit menu. (Figure 19).

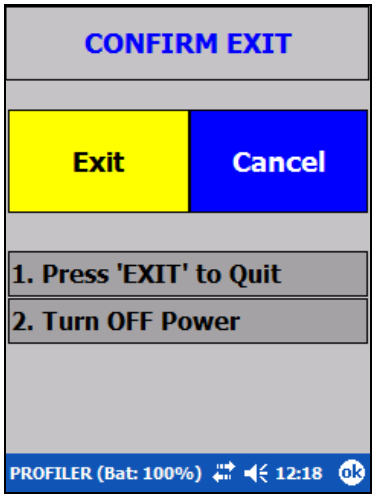


Figure 19: Profiler Exit menu.

3. Once in the Exit menu, depress the Set System Time, Date and Power button ***two (2) times*** (Figure 20).

Figure 20: Set System Time, Date, Power button.

4. After depressing the button two (2) times the Exit Menu screen will change and additional menu fields will appear (Figure 21):

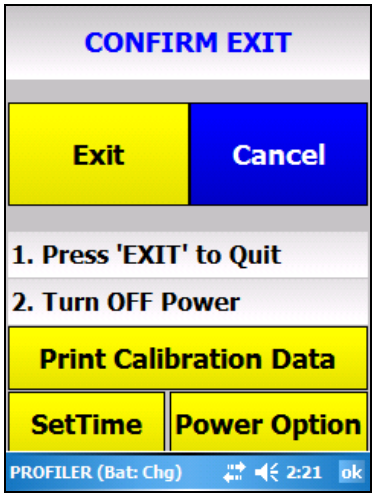


Figure 21: Set System Time, Power Option.

5. To set the system time and date tap the **Set Time** field. This will open the Windows System settings Clocks and Alarms menu window and allow the user to set the appropriate local time and correct date (Figure 22).

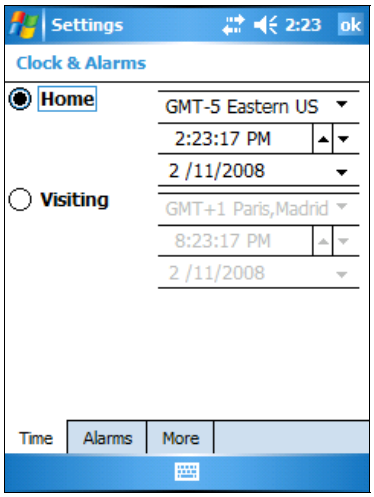


Figure 22: Windows Settings Clocks and Alarms menu.

6. Once tthe time and date have been set, the user can modify the Power settings by selecting **Power Options**. This will open the Windows\PDA rechargeable battery settings window. The user can see the state of both the main and backup battery (Figure 23).

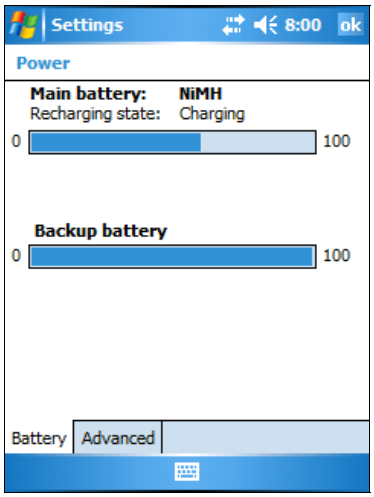


Figure 23: Windows Power Settings menu.

7. The user can access the Advacned power options by tapping the **Advanced** tab.

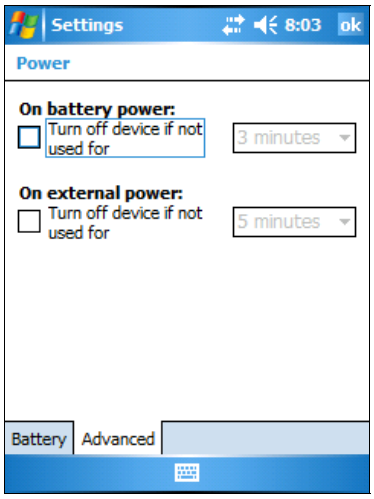


Figure 24: Windows Power Settings Advanced menu.

8. The user can now modify the On Battery Power and On External Power options; however, GSSI recommends that these settings be left at the factory default, i.e., OFF. If these settings are turned ON by the user, unpredictable PDA operation may result and loss of data may occur.

2.3 Recall Setup

The operator can store up to 28 user-defined setups in the EMP-400 PDA memory.

1. From the Main menu select **Recall Setup (**Figure 25). The user should select the desired Setup number with the PDA stylus and then press the **Enter** key on the PDA.

- All the saved data acquisition parameters will be loaded with the exception of the GPS setup and the system calibration parameters.
- The WAAS GPS must be turned on manually and a GPS test conducted to assess the GPS signal condition and GPS validity. If the operator is using an external GPS system, it should be connected to the PDA serial communications port at this time (see Settings for an External GPS System).
- The system Field Calibration and User calibration should be performed prior to the start of a survey. (This is discussed in detail in Chapter 2, Section 2.4 – System Calibrations)

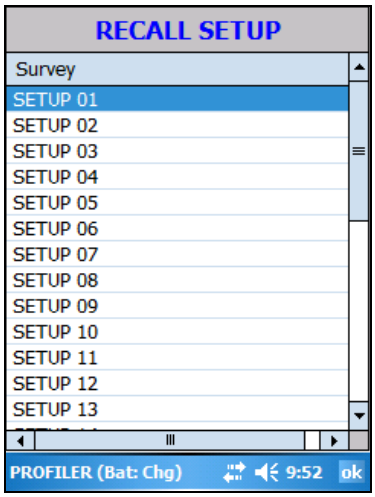
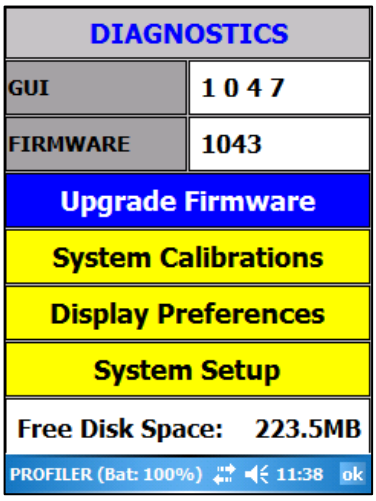


Figure 25: Recall Setup menu.

2.4 Check System Diagnostics Parameters

Diagnostics Menu

Examine the parameters in the Diagnostics menu (Figure 26) to ensure that the system is properly configured by selecting **Main > Diagnostics**.



- GUI (page 19)
- Firmware (page 19)
- Upgrade Firmware (page 20)
- System Calibrations (page 20)
- Display Preferences (page 21)
- System Setup (page 26)

Figure 26: System Diagnostics menu. CHANGE FRIDAY

GUI

The Diagnostics menu contains information on the **G**raphic **U**ser **I**nterface (GUI) version installed on your PDA. This field is for information purposes only and cannot be changed or accessed by the user.

Firmware

This menu contains information on the Firmware version number installed on your PDA. This field is for information purposes only and cannot be changed or accessed by the user.

Upgrade Firmware

This function can only be accessed by the user with a GSSI supplied self extracting installation update file.

System Calibrations

The Systems Calibrations section of the EMP-400 allows the user to perform several calibration functions. This menu controls the Field Calibration, User Calibration and Free Space Calibration functions of the instrument.

Caution: The user should **NEVER** run the EMP-400 **Free Space Calibration**. The EMP-400 has been Free Space calibrated at the factory. Once the calibration is performed, the calibration files are stored in the system memory (Figure 27).

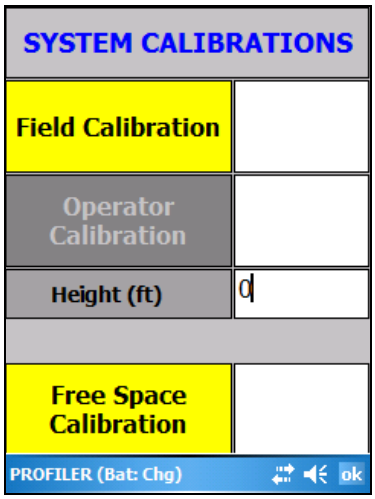


Figure 27: System Calibration menu.

Important Notice Regarding EMP-400 Calibration Files

The user should **never** move or delete the Profiler EMP-400 Calibration files from their location in the PDA. Moving or deleting these files will compromise the EMP-400 calibration. They are not user accessible files.

Copies of these files can be found on the Profiler Accessory CD that was supplied with your system. If for any reason you suspect that the calibration files have been corrupted, or are mistakenly deleted, they can be copied from the backup CD directly into the PDA \\My Windows Mobile-Based Device\Program Files\Profiler\ directory. These backup files allow the user to restore the system calibration and parameter files.

GSSI recommends that these files be copied from the Profiler Accessory CD and stored in a safe location on your PC as additional backup in the event the Accessory CD and the calibration files on it are lost or become corrupted or damaged.

The Profiler EMP-400 employs a continuously self-calibrating system. In the event of system calibration failure (or corruption or deletion of the system calibration file) the EMP-400 will prompt the user with an error message: "Failed To Open Profiler Params File," or "Failed To Open Calibration File." If the user is prompted with this warning, the backup calibration and

parameter files will have to be re-loaded into the PDA\\My Windows Mobile-Based Device\Program Files\Profiler directory.

If the user inadvertently selects the Free Space Calibration function while performing system Field and User calibrations, the following Warning Message will be displayed (Figure 28).

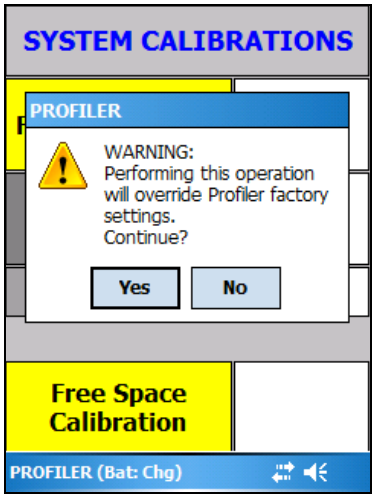


Figure 28: Free Space Calibration system warning.

- If this warning should appear, the user should select **No**.
- If the operator inadvertently selects **Yes**, the Profiler will immediately begin the Free Space Calibration procedure. At this point, the operator must let this procedure run until completion. If the operator attempts to terminate the calibration procedure before it is completed, the Profiler interface will freeze. At this point, it will be necessary for the operator to re-boot the PDA and turn off the Profiler and re-establish Bluetooth communications between the PDA and the EMP-400 (see Section 1.2).
- Once the Free Space Calibration is complete, the operator will have to replace the Profiler calibration files (see Appendix D Replacing Profiler Calibration Files).

Display Preferences Menu

After selecting the appropriate data display and the display limits, return to the Main menu and select **Diagnostics > Display Preferences** (Figure 29).

- Screen Colors (page 22)
- Data Display Colors (page 23)
- Data Display Limits Setup (page 23)
- Positioning Display (page 25)
- Map Smoothing (page 25)
- Data Smoothing (page 25)

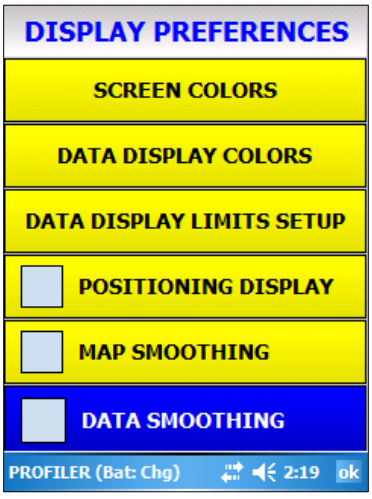


Figure 29: Display Preferences menu.

Screen Colors

The Screen Colors menu enables the user to customize all of the system setup menus, tool bar labels and background colors. Customization of the system displays is entirely up to the user. In some cases, it may be desirable to change the colors of certain fields to enhance the menu display in high (or low) ambient light conditions. Both the Text and Background color of the EditBox, Header, Label and function Button may be customized.

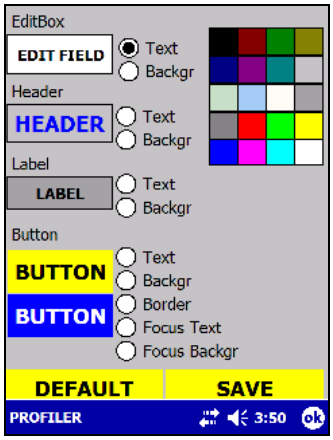


Figure 30: Screen Colors menu.

Background: To change the Background, select **Backgr** next to the specific field you wish to customize and then select the desired color from the color palette on the left of the display.

Text: To change the color of the Text, select **Text** next to the specific field you wish to customize and then select the desired color from the color palette on the left of the display.

Function Button: Customization of the Function button includes the Text, Background, Border, Focus Text and Focus Background. Customization of the Text and Background for the Function buttons are the same as that for the EditBox, Header and Label.

Function Button Border: The function Button Border (the border around the Function button) Focus Text (active menu selections under the function Button) and Focus Backgr (the background behind the Focus Text) allow the user to further customize the function Buttons as desired.

- GSSI recommends that the user experiment with these functions. Once the desired colors have been chosen, select **Save**.
- At any time, the user may return the system to the default color settings by selecting **Default**.

1. When you are satisfied with your changes, select **Save** > **OK** from the PDA Status Bar to return to the Display Preferences menu.
2. Select **OK** from the PDA Status Bar to return to the Diagnostics menu.
3. Select **OK** from the PDA Status Bar to return to the Main menu.
4. Select **Collect Data** to return to the Collect Data menu.

Data Display Colors

The Data Display Colors menu allows the user to select a specific color for the In-Phase, Quadrature, Conductivity and/or Magnetic Susceptibility of the transmit frequencies selected for data collection.

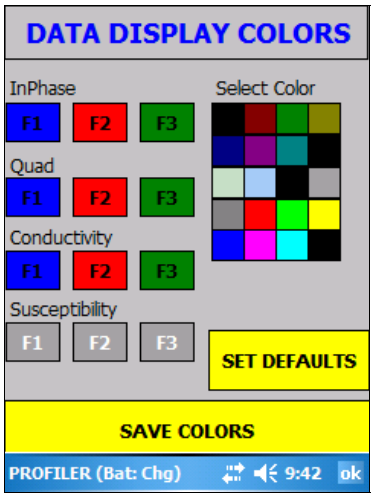


Figure 31: Data Display Colors Setup menu.

1. To apply a color to a given component, select the desired Frequency number box (F1, F2, or F3) of the desired component: In-Phase, Quadrature, Conductivity or Susceptibility, and then select the desired color from the color pallet to the right. The selected color will now be applied to the selected frequency(s) and component(s).
2. When you are satisfied with the color(s) select **Save Colors > OK** from the PDA Status Bar to return to the Display Preferences menu.

Caution: GSSI recommends that the user avoid selecting light grey (color) or gray (color) as data display colors for the line graph display. These colors will be difficult to see against the white data display background.

Data Display Limits Setup Menu

This menu is used to set the Display Limits for the selected frequencies and components used for data collection. To access the Display Scale menu, select **Diagnostics > Display Preferences** > **Data Display Limits Setup** (Figure 32).

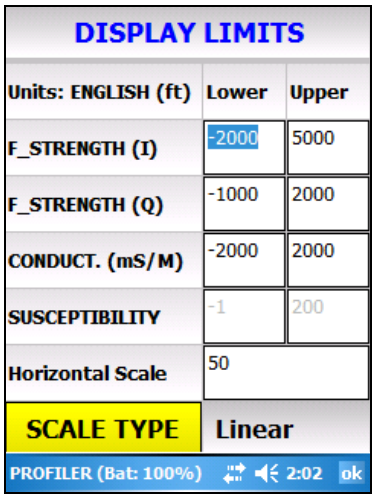


Figure 32: Display Limits menu.

The Display Scale menu enables the user to select the minimum and maximum data values which will be displayed on the screen for the display of Graphic or Alphanumeric data.

- If a Line or Bar Graph display is selected, the user has the option of selecting a Linear or Logarithmic Graphic display scale. The user can enter the desired values for Lower and Upper bounds of the data display by selecting in the white values field.

Units: This parameter displays the distance units selected by the user for survey grid parameters. In Figure 37, the Units for the Horizontal Scale are in Feet. The user can select either English or Metric units.

F_Strength (I): The data values for the F_Strength (I) are displayed in parts per million (ppm).

F_Strength (Q): The data values for the F_Strength (I) are displayed in parts per million (ppm).

Conduct. (mS/m): The data values for the Apparent Conductivity (σ_a) are displayed in Mill Siemens per meter (mS/m) when data is collected at 15 kHz using the low carry handle.

Susceptibility: The data values for the magnetic Susceptibility are displayed in X_m. Magnetic susceptibility is a dimensionless unit.

Horizontal Scale: This will adjust the full-scale width of the Line Graph display to a value selected by the user. All Line Graph data is plotted from left to right on the line graph display. For example, the user is profiling on the X-axis (X min=0, X max=100) and the horizontal scale was set to 100, the full width of the display would be used to display the entire 100 feet of data. At this scale, small features may be compressed and difficult to distinguish. The user can select a smaller scale of 10, 20, or 50 feet and the horizontal scale of the display would then correspond to the specified distance in feet (in the stationary mode) or the reading number (in the continuous mode). The screen will automatically scroll one-half the display width when the plotted line graph data reaches the right hand edge of the data display.

Scale Type: This parameter allows the user to change the data display scale from Linear to Logarithmic.

Note: It is often useful to collect a dummy transect across the site **after** the instrument has been calibrated and the In-Phase zeroed in order to ascertain the range of measured values at the site.

This allows the user to set the lower and upper bounds so that high positive and negative values for the In-Phase and Quadrature data are not clipped off the top or bottom of the display. If, during the course of collecting the dummy transect, the user notes that the data is being clipped on the display, we recommend that the Lower and Upper bounds on the Graphic display be reset or the scale of the Graphic display set to a Logarithmic scale. The values entered for Lower and Upper bounds are for display purposes only. These values do not affect the data values stored in memory by the unit during data collection. Once the desired Graphic scale and values for the Lower and Upper bounds are entered, select **OK** from the PDA Status Bar to return to the Data Collection menu.

Positioning Display

The Positioning Display selection enables the user to open the Positioning display screen when in the data collection mode. To enable this function, tap in the box next to **Positioning Display**. An X should appear (Figure 33). During data collection, it is possible to toggle between the Data and Positioning display by tapping on the data acquisition display screen.

- If Data Display is enabled, the acquired data will be displayed on the PDA screen as it is collected in the display format selected by the user (See Display Limits Setup Menu).
- If Position Display is enabled, the survey location points, as defined by the survey grid parameters will be displayed as circular dots as data is collected. Survey marks will be displayed as red circles (Figure 33?????).

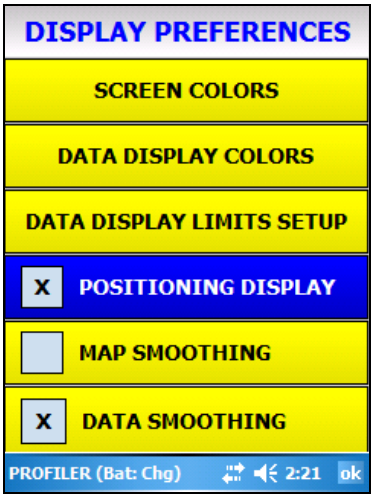


Figure 33: Display Preferences menu. Positioning and Data Smoothing Enabled.

Map Smoothing

The Map Smoothing acts to smooth the level contours on the contour map display in the Review Data section of the interface (see Section 3.4 Review Data). To enable this function, tap in the box next to Map Smoothing selection in the Display Preferences Menu (Figure 33).

Data Smoothing

The Data Smoothing filter is a 5-point center-weighted triangular filter that is applied to the data during data collection. The user has the option to enable or disable this function. **To ensure high data quality, GSSI recommends that this filter remain on during data collection.**

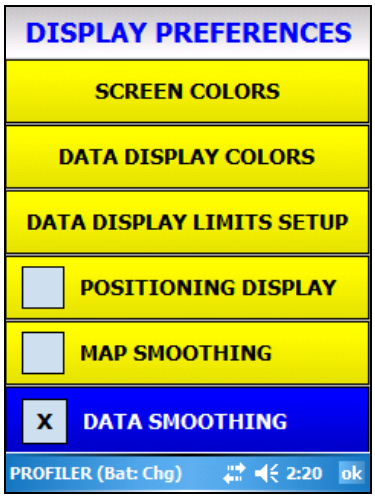


Figure 34: Display Preferences menu. Data Smoothing Enabled.

Caution: Under no conditions should the user modify the SYSTEM Screen parameters. These control the display window orientation. The display window orientation is set at the factory to Portrait by default. Changing the window orientation could lead to unpredictable operating (display) results when running the Profiler interface. GSSI assumes no responsibility for Profiler interface operating problems if the display orientation is changed by the user.

System Setup Menu

The System Setup menu contains all of the entry fields required for system data storage, the system metronome beeper, to enable the WAAS GPS function and to conduct the GPS test: To access this menu, select **Main > Diagnostics > System Setup.**

- Save Data (page 26)
- Beep (page 27)
- GPS Test (page 27)
- GPS Device (page 28)
- GPS Baud rate (page 29)
- Bluetooth Port (page 29)

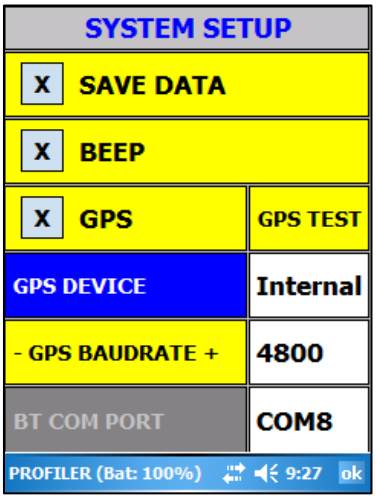


Figure 35: System Setup menu.

Save Data

The EMP-400 Save Data power on default is **ON**.

- If the user wishes to collect data files for test purposes (e.g., evaluating system response and for setting the data display limits) and does not wish to save the data, the user can turn Save Data Off by selecting this option. This field will toggle between ON (X) and OFF.
- If the user turns the Save Data Off, the user must remember to turn Save Data On prior to collecting data for a survey. If the user turns Off the PDA and the EMP-400 and the Save Data has been left **Off**, the system will power on with the Save Data **Off**. The user must remember to turn **On** the Save Data before conducting a survey.

Beep

The Beep function power on default is **On**. It is recommended that the user leave the beep **On** at all times. The Beeper serves several useful functions:

- It notifies the user when a data point has been collected.
- In the Continuous (timer) mode, the beep serves as a useful pace timer when collecting data.

GPS Test

If the WAAS GPS or an external high-resolution GPS is to be used to collect GPS data, the user must conduct a GPS Test. Selecting GPS Test will open the GPS Test display.

The only user selectable field on the GPS Test display is the GPS Validity setting. This is discussed in detail below.

GPS Test Messages

GPS Status: **Valid/Invalid:** GPS validity is determined by the number of satellites and/or the HDOP (**H**orizontal **D**ilution **o**f **P**recision). The user selects the number of visible satellites as the criteria for determining GPS validity. In this case, the number of satellites should be ≥ four. The **Validity** selections available to the user are:

- **Satellites ≥ 4:** If the number of satellites equal to or greater than four, the GPS solution is valid. This is the recommended setting for both the WAAS and external GPS validity.
- **Satellites≥ 3:** If the number of satellites is equal to or greater than three, the GPS solution is valid.
- **HDOP < 2**: If the HDOP is less than two (2) the GPS solution is valid.
- **No Conditions**: When no conditions are applied to the Validity the GPS is always valid. **This setting is not recommended.**

Latitude: This field displays the GPS calculated Latitude.

Longitude: This field displays the GPS calculated Longitude.

GPS UTC: GPS Coordinated Universal Time.

 # Satellites: The number of satellites from which the GPS system is currently receiving a signal.

HDOP: The **H**orizontal **D**ilution **o**f **P**recision (HDOP) allows one to estimate the accuracy of GPS horizontal (latitude/longitude) position fixes by adjusting the error estimates according to the geometry of the satellites used. In probability terminology, HDOP is an additional variable

that allows one to replace the overall accuracy estimates with *conditional* accuracy estimates for the given HDOP value.

Note: Prior to conducting a survey using GPS, it is highly recommended that you consult a mission planner to determine satellite coverage and visibility at the location where you will be conducting the survey. A free QuickPlan program is available from TRIMBLE®. It can be downloaded from the following URL: www.trimble.com/support_trl.asp?NAV=Collection-3627 (See also Appendix A). This program contains complete instructions on its use and the URL above can be visited regularly to download updated GPS almanacs which contain position corrections for GPS satellites. Almanacs should be downloaded regularly to assure you have the most recent updated GPS satellite data.

Note: The average cold-start time for the WAAS GPS is approximately 5 minutes. In some areas signal acquisition for the WAAS may be difficult. It is advisable when using the WAAS GPS to allow 10-15 minutes for the WAAS to acquire a signal and to establish a stable fix before beginning the survey.

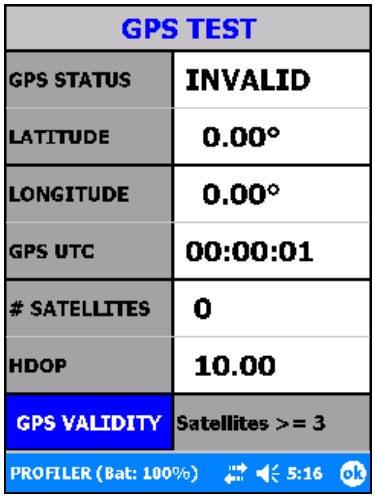


Figure 36: GPS Test menu.

GPS Device

The appropriate WAAS communications port for the RECON-400 PDA and EMP-400 communications have been preset at the factory.

- The default setting for the WAAS GPS comm. Port is Internal.
- The default setting for an external GPS comm. port is External.

Settings for an External GPS System

The Profiler is designed to accept a NMEA $GPGGA string (see Appendix A for an example of a GGA string). If the Profiler is to be configured with an external GPS or DGPS, the GPS system output format should be configured as follows:

- 8 bits
- N (No) parity
- 1 (stop bit)

- BAUD: 4800/9600
- The data output rate from an external GPS should be set to as close as possible to the data acquisition rate of the EMP-400. In the Continuous mode the operator should set the Interval to the same rate as the GPS output. In some cases, the data acquisition rate will be higher than the data output rate from the external GPS.

GPS Baudrate

This setting only applies when using an external GPS device. This value toggles between 4800 and 9600. 4800 BAUD is the recommended setting for EXTERNAL GPS devices.

Bluetooth COM Port

The Bluetooth communications port cannot be changed or disabled by the user. The Bluetooth port cannot be used to communicate with any other device except the Profiler EMP-400.

2.5 Check System Parameters

The Select Parameters menu contains all of the entry fields for user selectable data acquisition parameters: To access this menu, select **Main > Select Parameters.**

Select Parameters Menu

- Mode (page 29)
- Interval (page 30)
- FREQ 1 (page 30)
- FREQ 2 (page 30)
- FREQ 3 (page 30)
- Orientation (page 31)
- Stacking (page 33)

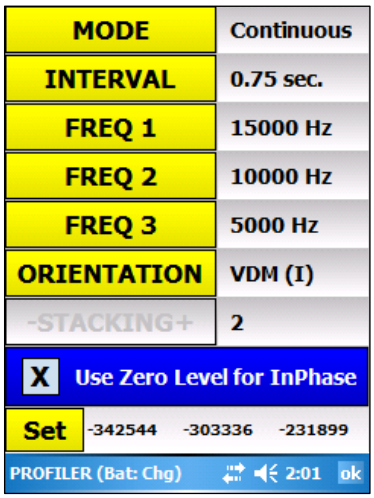


Figure 37: Select Parameters menu.

Mode

This enables Continuous (time) or Stationary (point-to-point) data collection. Select either Continuous or Stationary mode. The selection field will toggle between these two options.

Continuous Mode: This parameter allows the user to collect data in a timed manner. When collecting one (1) frequency the maximum data collection rate is 0.25 sec. When collecting two (2) frequencies the maximum data collection rate is 0.5 sec. When collecting three (3) frequencies the maximum data collection rate is 1 sec.

- In Continuous mode, data collection is initiated by selecting **Start Data Collection**, then depressing the Enter (↵) key on the RECON PDA keypad (Figure 8), or by depressing the Start button on the RF key fob (Figure 16). The system will beep and the Blue

communication status lights will blink when the data has been recorded and a data point will appear on the PDA data display in the data display format selected by the user. The rate at which the EMP-400 will collect Continuous data is selected in the Interval field.

Stationary Mode: In stationary mode, data collection is initiated by selecting **Start Data Collection**, then depressing the Enter (↵) key on the PDA keypad, or by depressing the Start button on the RF key fob. The system will beep and the **Blue** communication status lights will blink when the data has been recorded and a data point will appear on the PDA data display in the data display format selected by the user.

Interval

Interval is the time interval in seconds between successive readings when operating in the Continuous mode. If you are collecting data in the Continuous mode, select the desired time Interval (Figure 38). When you are satisfied with the selection, select OK from the PDA Status Bar to return to the Select Parameters screen.

Figure 38: Time Interval menu.

FREQ 1

The first transmit frequency.

FREQ 2

The second transmit frequency.

FREQ 3

The third transmit frequency.

To Select Frequency

The user can select from one (1) to three (3) frequencies for data collection. At least one (1) frequency must be selected prior to data collection.

1. Select **FREQ 1** from the Select Parameters menu. Figure 39 illustrates the transmit frequency selection list Select Frequency menu below.

Figure 39: Select Transmit Frequencies menu.

2. After selecting the desired transmit frequency (s) tap **OK** on the PDA Status Bar to return to the Select Parameters screen.

- In order to collect data with the EMP-400 at least one frequency must be selected.
- If the user selects more than one (1) transmit frequency for data collection, the user must select the frequencies in numerical order, i.e., FREQ 2, FREQ 3.
- To deselect multiple transmit frequencies i.e., FREQ 2 and/or FREQ 3, the user must select FREQ 3 *first* and then tap **None** on the Select Frequency list and then tap **OK** on the PDA Status Bar menu. This sequence is then repeated with FREQ 2.

Orientation

This parameter writes the orientation of the transmitter and receiver dipoles used during data collection into the EMP-400 file header. In the Vertical Dipole Mode (VDM) and the Horizontal Dipole Mode (HDM) either the in-line and broadside instrument orientations may be selected. The diagram shown in this menu is a birds-eye view of an operator holding the EMP-400.

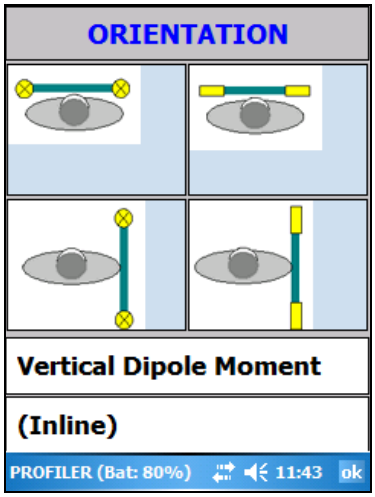


Figure 40: Dipole Orientation menu.

There are four (4) possible dipole orientations:

- On the left of the screen is the Vertical Dipole Mode. The two instrument orientations are VDM broadside (top left) and VDM inline (bottom left).
- On the right of the screen is the Horizontal Dipole Mode. The instrument orientations are HDM broadside (top right) and HDM inline (bottom right).

After selecting the desired instrument orientation, tap **OK** on the PDA Status Bar to return to the Select Parameters screen.

Profiler Tilt Error Message

The EMP-400 electronics incorporates a tilt sensor, which senses the system orientation of the instrument with respect to system horizontal i.e., the Vertical Dipole Mode. This sensor will detect if the instrument is rotated 45° from the specified dipole mode.

Caution: Performing the Field and User calibrations in one dipole orientation and then collecting data in the other will lead to erroneous data values.

- For example, if the user selects the Vertical Dipole Mode in the Orientation menu and then rotates the EMP-400 45°, the PDA will display a "Profiler Tilt Error" message (Figure 41).
- If the user selects the Horizontal Dipole Mode in the Orientation menu and then rotates the EMP-400 45°, the PDA will display a "Profiler Tilt Error" message Figure 41).
- If the instrument is in the Vertical Dipole mode and is rotated 180° e.g., upside down, the system will display a "Profiler Tilt Error" (Figure 41).
- The tilt sensor does NOT affect the Orientation setting selected by the user, or the value for the instrument orientation that is stored in the file header. The user must enter the correct instrument orientation in the Orientation Parameters menu. If the tilt sensor detects an orientation error and the error is not corrected in the Orientation menu, the system will write an X into the Tilt column of the data file.

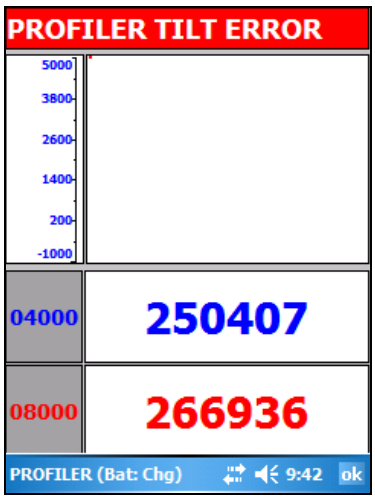


Figure 41: Profiler Tilt error.

Stacking

The Stacking function will operate in both the Continuous and Stationary modes. Stacking is the number of successive readings averaged at each data collection point. Stacking is used to suppress random cultural noise and improve the signal-to-noise ratio of the data. Stacking is useful in areas where random noise, cultural noise or intermittent noise 'spikes' may be affecting the quality of the data.

In the Continuous mode, the stacking values are selected automatically. The EMP-400 is designed to maximize the number of stacks for a selected data acquisition rate and number of transmit frequencies. The total number of stacks is a function of the number of frequencies and the speed of operation. For example, if the operator is collecting three (3) frequencies at the maximum rate of one (1) reading per second, the Stacking is automatically set to 2. If the operator is collecting one frequency at one (1) reading per second, the Stacking is automatically set to 8. If the operator is collecting one (1) frequency at 4 reading per second, the Stacking is automatically set to 1.

In the Stationary mode the user selected values are one (1) (no stacking) through 64. If stacked data is to be acquired, select Stacking from the Select Parameters menu. The selection field will increment through the available stacking values.

- In the Continuous mode the number of stacks is selected automatically and is a function of the number of transmit frequencies and the time interval selected by the user.
- Stacking will slow down the data acquisition speed. The absolute decrease in collection speed will be determined by the number of frequencies collected and the number of stacks applied.
- In Stationary mode, the user may increment (increase) the stacking value by tapping the right (+) side of the yellow stacking field. To decrement (decrease) the stacking value, tap the left side (-) of the stacking field (Figure 42).

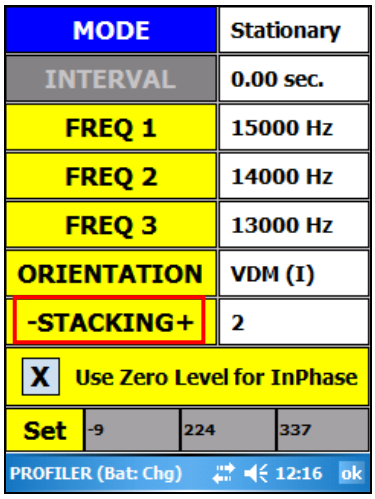


Figure 42: Increase or decrease Stationary mode Stacking.

- Once the desired level of stacking is set, tap **OK** on the PDA Status Bar to return to the Main menu.

2.6 System Calibrations

Prior to data collection, the Profiler must be calibrated for the local site conditions. This calibration is performed to compensate for the presence of the operator and the PDA and to compensate for local ambient noise conditions. In addition, the system must compensate for the presence of an external GPS system if one is to be used during data collection. The Field Calibration must be performed first, and then the Operator Calibration.

Note: Collecting Apparent Conductivity Data. When the objective of the survey is to collect apparent conductivity (σ_a) data, the Profiler **must** be operated with the low carry handle, and at least one (1) of the transmit frequencies must be 15 kHz. The algorithm that converts the Quadrature values to apparent conductivity has been optimized for the 15 kHz transmit frequency for 1.219 meter (4 foot0 coil spacing. Extensive modeling and field testing has determined the data collected at other frequencies, or at heights greater than 1.5 feet, will yield apparent conductivity values (σ_a) that are higher (or lower) than those that would be measured by similar induction instruments at the same location.

To perform the System Calibrations, select the **Main > Diagnostics > System Calibrations** (Figure 43).

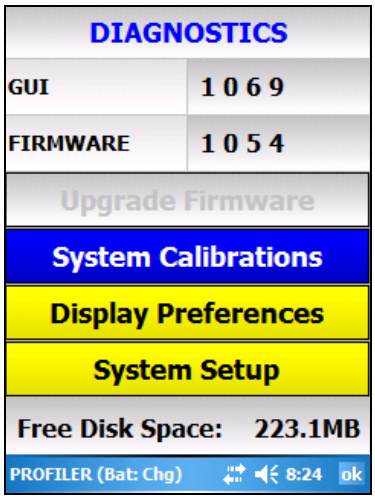


Figure 43: Diagnostics menu.

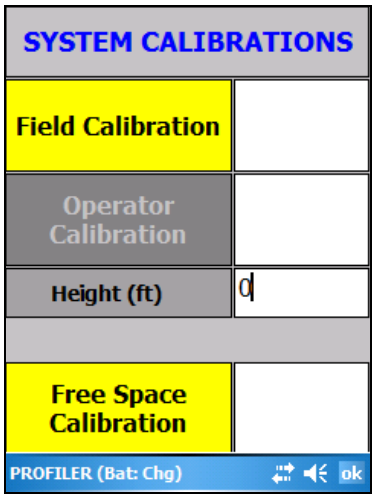


Figure 44: System Calibrations menu.

Field Calibration

1. Prior to performing the Field Calibration, make certain that you have selected the desired Transmit Frequencies (Figure 39).
2. Remove the PDA from the EMP-400 if using the PDA mount.
3. Place the EMP-400 unit on the ground.

- If the low-carry handle is to be used for data collection, this should already be attached.
- If the operator is using the hip-height carry strap, this should already be attached.

4. Walk at least 12 feet away from the EMP-400 with the PDA. The operator should (not interpose their body) <(delete) stand (??) between the PDA and the EMP-400 during the calibration process, or Bluetooth communication may be lost.
5. Select **Field Calibration** (Figure 45).

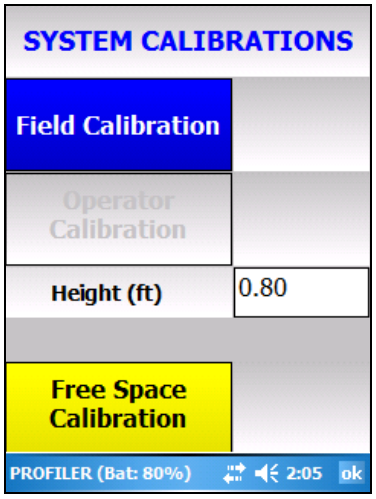


Figure 45: Field Calibration menu.

Note: It is irrelevant if the Height field has been filled with the Profiler operating height. When the Field calibration is run by the user the system ignores any value written in this field.

6. The EMP-400 will begin to calibrate for the selected Transmit frequencies. When the Field Calibration is complete, the display will prompt **Done (**Figure 46).

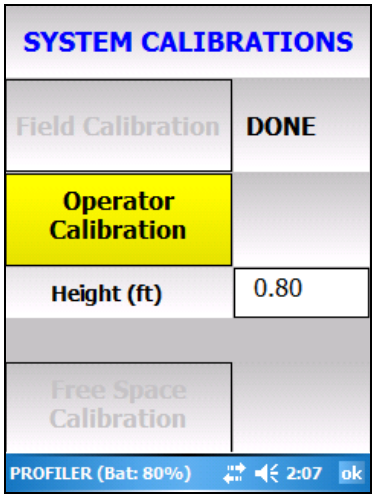


Figure 46: Completed Field Calibration.

Operator Calibration

Note: Prior to conducting the OPERATOR calibration, the operator should remove **all** metallic objects from their person. The user should never carry wireless devices e.g. cell phones, Personal Data Assistants, etc, during calibration or system operation. If using an external GPS, it is necessary that the operator to carry/wear the GPS system they will be using while performing the Operator Calibration.

1. Return to the EMP-400. Enter the **Height** (in feet or meters) at which the survey data will be collected.

- Whether using the low-carry handle or the hip-height carry strap, measure the distance from the coils to the ground surface. This measurement must be made with the coils in the orientation in which data is to be collected.
- When collecting data in the Vertical Dipole Moment (VDM), the measurement should be made from the horizontal seam in the coil cover.
- When collecting data in the Horizontal Dipole Moment (HDM), the measurement should be made from the center of the coil cover.

2. Pick up the EMP-400 and position it at the height at which data will be collected.

3. Select **Operator Calibration**. The EMP-400 will begin to calibrate for the selected Transmit frequencies. When the Operator Calibration is complete, the display will prompt **Done (**Figure 47).

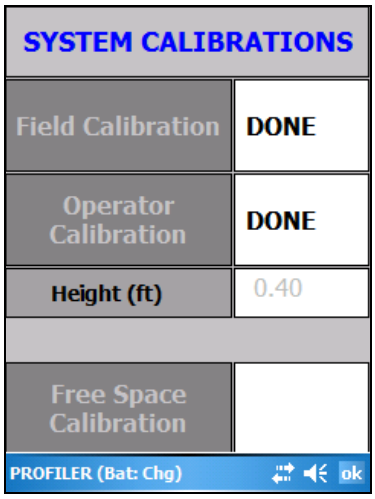


Figure 47: Completed Operator Calibration.

System calibration is now complete.

Note: The EMP-400 System Calibration only calibrates for the currently selected Transmit Frequencies. If the operator changes the Transmit Frequencies after the initial calibration, it will be necessary to re-calibrate the system for the new Transmit Frequencies.

Set In-Phase Zero Level

This function performs a zero level adjustment of the In-Phase components of the selected frequencies to remove any In-Phase signal offset. The zero level values are set for display purposes only. The data is recorded and stored in raw form. The values used to zero the data in the field are saved in the file header.

- The acquired In-Phase data is stored with the raw In-Phase component values.
- The user can also set the line-frequency filter for either 60 Hz or 50 Hz line noise.
- The zero level setting is performed only after the operating frequencies and line frequency filter have been selected by the user and the Field and Operator Calibrations have been performed.
- The Quadrature component values are not zeroed prior to data acquisition.

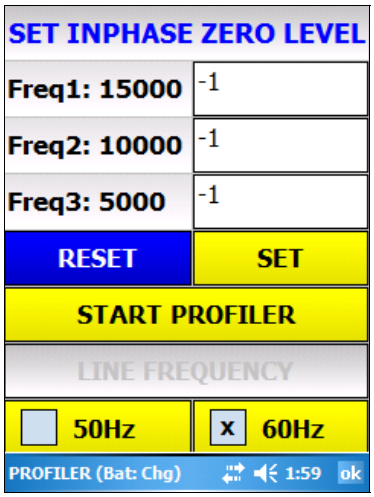


Figure 48: In-Phase Zero Level and Line Filter menu.

The user should set the In-Phase zero levels in an area where they are confident they are not in proximity to buried ferrous metal or near metallic surface objects. The user should be holding the instrument at the height at which data will be collected i.e., either with the shoulder strap or low-carry handle. The user should remove *all* metallic objects from their person prior to setting the zero levels.

The EMP-400 has been designed to identify noisy line frequency bands. The Line Frequency selection enables either the 50 Hz or 60 Hz line frequency filter. The user should select the appropriate line frequency filter setting for the region in which they are operating e.g., in the U.S. the filter setting should be 60 Hz; in Japan and Europe this filter setting should be set to 50 Hz.

Set In-Phase Zero

1. Select **Set** from Select Parameters menu.
2. Select **Start Profiler** form Set Inphase Zero menu.
3. The EMP-400 will begin to beep and the **Blue** communication status lights on the EMP-400 will begin to flash. The user will see a series of numbers displayed for the each of the selected transmit frequencies.

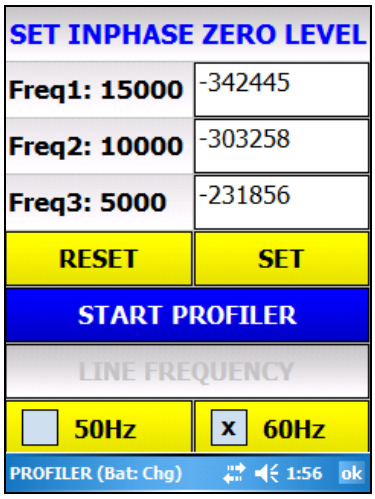


Figure 52: In-Phase Zero Level start.

4. The values for the selected frequencies will begin to rise or fall depending upon the frequency selected. The Set In-Phase Zero display field will now change to **Stop Profiler.**

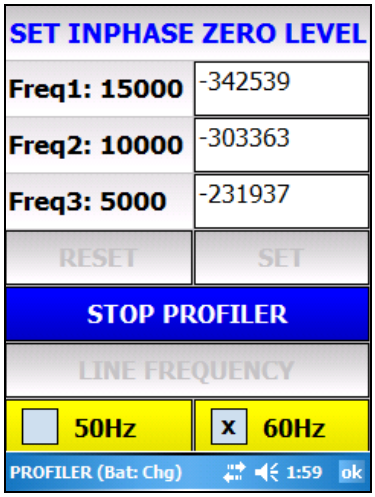


Figure 53: In-Phase Zero Level running.

5. The user should wait approximately 10-20 seconds for the values to stabilize, i.e., the rate of change in In-Phase values will decrease and stabilize.

6. After the In-Phase signals have stabilized select **Stop Profiler.**

7. Tap **Set** in the Set In-Phase Zero Level menu.

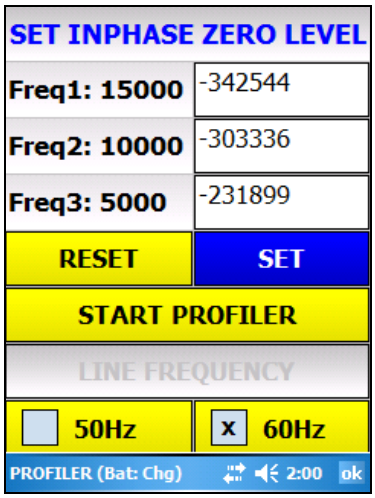


Figure 54: In-Phase Zero Level set.

8. The user should then select the Use Zero Level box. A black **X** will appear in the box indicating that the displayed In-Phase components will have the set zero level values added (or subtracted) from the acquired In-Phase values.

9. To reset the In Phase Zero levels select **Reset**. This will set the In Phase Zero Levels to -1. The Set In Phase Zero Level procedure should then be repeated.

2.7 Select Grid Configuration (Grid Config.)

Grid Config Menu

The Grid Config menu (Figure 49) contains all of the entry fields for user selectable grid configuration parameters including the coordinates for the survey limits, the distance between instrument readings and the spacing between successive survey transects. To access this menu, select **Main > Grid Config**.

- XMIN (page 41)
- XMAX (page 41)
- YMIN (page 42)
- YMAX (page 42)
- Step (page 42)
- Spacing (page 42)
- Mark Spacing (page 43)
- Grid Type (page 43)
- Direction (page 43)
- Units (page 45)

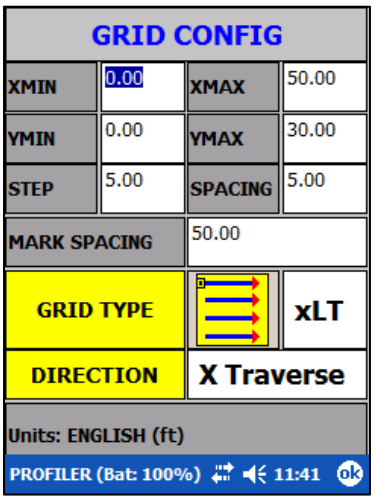


Figure 49: Grid Configuration menu.

Setting Grid Config – Set Units

The user must select the survey units in the Project Parameters menu prior to setting the Grid Parameters. If the user sets the Units to METRIC, then sets the Grid Parameters, and then resets the Units to ENGLISH in the Project Parameters menu, the Grid Parameter units will contain conversion rounding errors. At this point the user would have to re-enter the correct Grid Parameter values prior to collecting data.

- All survey grid parameters can be selected by selecting the white value field next to each parameter. This will cause the PDA on-screen keyboard to pop-up at the bottom of the menu display.
- To enter numeric information, select the numeric keypad function on the keyboard by selecting the 123 box on the upper left corner of the keyboard. The numeric keypad has large keys, and it will facilitate entering in numeric values in the Grid Config menu.

XMIN

The minimum coordinate for the X-axis. This value can be negative or positive.

XMAX

The maximum coordinate for the X-axis. This value can be negative or positive.

YMIN

The minimum coordinate for the y-axis. This value can be negative or positive.

YMAX

The maximum coordinate for the Y-axis. This value can be negative or positive.

Step

Stationary Mode: This parameter is the actual distance interval between successive instrument readings.

Continuous Mode: This parameter is the relative distance between successive instrument readings. The distance between steps in the Continuous mode is a function of the data acquisition rate (Interval setting) of the instrument, and the speed at which the instrument is moved over the surface.

- The maximum positive value for Step cannot exceed the maximum X or Y transect value. i.e. the Step value cannot exceed XMax or YMax.
- The value for Step must always be positive.
- Fractional values for the Step, i.e., 0.5, can be entered by the operator. If fractional values are used, the Step (station) number will increment at the value selected.

Note: It is strongly recommended that only whole number values (1, 2, 3, etc.) or even fractional values (0.25, 0.5, 1.25) be used for the Step value. If the step value is number such than when divided into the transect maximum it yields a repeating decimal, the transect value will be rounded down.

- Example: the grid coordinates entered by the user are Y Min=0, X Min=0, Y Max=50 and X Max=50. The user enters a value of 0.75 for the Step, the X Max value will automatically be rounded down to 49.50 by the system when the user exits the Grid Config menu. This rule applies for any multiple of .75. e.g. the value 1.5, results in the repeating decimal fraction of 33.3333 if divided into 50.

Spacing

The distance interval between successive transects of the survey grid. The value entered for Spacing must be positive. When data is collected in Stationary mode this is the actual (desired) station spacing. When data is collected in Continuous mode this is (essentially) an estimate. We recommend that when collecting data in the Continuous mode that the user conducts a test transect to determine how many actual readings are acquired for a particular data rate and user 'pace' along a transect. The user can then adjust the Spacing value that more closely reflects the actual distance between readings.

Note: As with Step (see example above), fractional values for the Spacing, i.e., 0.5, can be entered by the operator. If fractional values are used, the Spacing number (transect separation) will increment at the value selected. Values for the Spacing that divide into the transect maximum (X or Y) and yield a result that is a repeating decimal will be rounded down.

Mark Spacing

The distance (in Feet or Meters) between fiducial marks placed in the data file when data is collected in Continuous mode.

Note: If the user is placing fiducial marks in the data, the user must be sure that the value entered into the Mark Spacing field is the actual distance at which marks are entered during data collection. MagMap 2000 uses these fiducial marks for linear interpolation of continuously collected data. If the value entered for Mark Spacing is incorrect, MagMap will interpolate the transect distances and the distances between the fiducial marks incorrectly. The user will then have to use the line start/end and mark editing functions in MagMap to input the correct distance between the marks and correct the overall length of the survey transects (see MagMap 2000 manual, Chapter 4: Editing of the Map).

Stationary Mode: The maximum number of readings in the Stationary modes is 500,000 readings.

Continuous Mode: The maximum number of readings in the Stationary modes is 500,000 (TO BE CHECKED) readings.

Grid Type

The small square box on the Grid Type icon indicates the starting point (origin location) of your survey. For example, select **X Traverse > Grid Type**. Figure 50 illustrates the X Traverse, X Grid Types below.

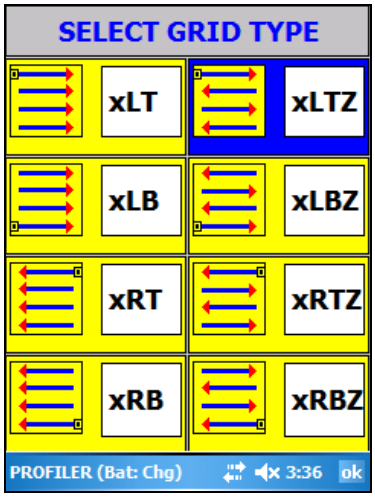


Figure 50: Select Grid Type (X) menu.

Direction

The system will toggle between X Traverse and Y Traverse. The traverse direction indicates the orientation of your survey along the X or Y-axis.

- If X Traverse is selected, the Grid Type field will display an icon indicating a traverse type oriented along the X (east-west) axis.
- If Y Traverse is selected, the Grid Type field will display an icon indicating a traverse oriented along the Y (north-south) axis.

This menu displays all the possible X-axis survey transect directions available to the user. The label convention is as follows

- xLB: X-axis profiling starting at the left bottom (LB) corner of the survey grid with all transects proceeding in the same direction (unidirectional).
- xLBZ: X-axis profiling starting in the left bottom (LB) corner of the survey grid with lines collected in a zigzag (Z) fashion (bidirectional).
- All of the icons on the left of the display are for surveys conducted in one (1) direction.
- All of the icons on the right of the display are surveys conducted in a zigzag manner. For example xRBZ indicates X profiling conducted in zigzag (Z) fashion starting from the right bottom (RB) of the survey grid.
- After selecting the appropriate icon, tap OK on the PDA Status Bar to return to the Grid Setup menu.
- To conduct profiling in the Y direction, select Direction for Y Traverse and Grid Type. Figure 51 illustrates the Y Traverse, Y Grid Types.

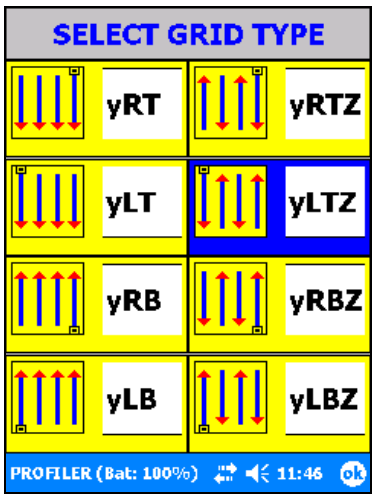


Figure 51: Select Grid Type (Y) menu.

This menu displays all the possible Y-axis survey transect directions available to the user. The label convention is as follows:

- yLB: Y-axis profiling, starting at the left bottom (LB) corner of the survey grid (unidirectional).
- yLBZ: Y-axis profiling starting in the left bottom (LB) corner of the survey grid with lines collected in a zigzag (Z) fashion (bidirectional).
- All of the icons on the left of the display are for surveys conducted in one (1) direction.
- All of the icons on the right of the display are surveys conducted in a zigzag direction. For example, yRBZ indicates Y-axis profiling conducted in zigzag (Z) fashion starting from the right bottom (RB) of the survey grid.

- After selecting the appropriate grid type icon, select OK from the PDA Status Bar to return to the Grid Config menu.

Units

This field displays the linear units that will be used in the Grid Config menu for XMIN, XMAX and YMIN and YMAX grid limit values and the transect Spacing. This field will toggle between English and Metric units. (See Setting Grid Config, page 39).

2.8 Review Parameters

Project Info Menu

Prior to starting the survey, it is often useful to record project information for permanent record as well as book keeping purposes. Figure 52 illustrates the Project Info menu. Site metadata often includes a Project name which may consist of a site location or job number. In addition, the identity of the operator, the date and time when the data was collected and the units (English or Metric) are all useful information to archive. This information may be entered into the PDA by selecting **Main > Review Parameters**.

- Project (page 45)
- Site (page 45)
- Operator (page 45)
- Next File (page 45)
- Date(page 46)
- Units (page 46)
- Project Parameters (page 46)

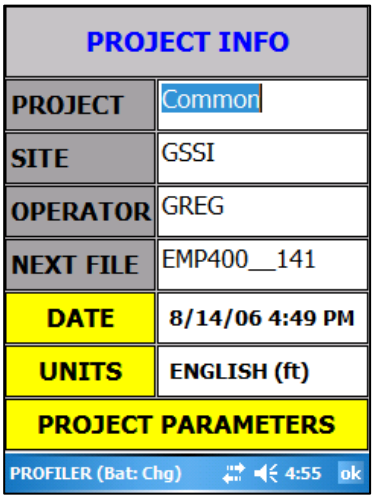


Figure 52: Project Information menu.

The following fields are available to the user for entering project specific information. This information will be saved in the Project file header when the data is written to memory. Information can be entered into these fields by using the PDA stylus and selecting the white value fields. This will enable the pop-up user keypad.

Project

This field can contain alphanumeric information regarding the specific survey being conducted, such as the job number or project name. This field is used to create a Project folder into which all data files will be written. This field can contain a maximum of 21 characters.

Site

This field can contain alphanumeric information on the job site or location. This field can contain a maximum of 21 characters.

Operator

This field can contain alphanumeric information on the system operator. This field can contain a maximum of 21 characters.

Next File

This field contains the alphanumeric information on the name and \or number of the ***next*** data file to be collected. The default data file names are written in the form EMP400__001.EMI. The file name format can be changed (with care) by the operator.

Note: The default file number starting at file EMP400__001 will increment by one (1) with each new file saved by the operator, however if the unit is turned off the data file number will not reset to 001. Example: The user collects five (5) files, EMP400__001 through EMP400__005, and then turns off the unit and transfers the files from the PDA. The next time that the system is used the *next* file collected will be numbered EMP__006. To reset the file number to EMP__001 the user must go to the Review Parameters menu and manually reset the file number, or change the Project folder or create new Project folder

User File Names

There are eleven (11) alphanumeric positions in the Next File field. The user can elect to change the default file name. Depending on the ***structure*** of the file name selected by the user, the Profiler program ***may, or may not*** attach a number extension to the file name depending upon which project folder it is written to, and if any previously acquired files have been removed from the working Project folder.

Examples:

- The Project folder is Common. The user selects the file name SITEA. The Profiler software will add a three dash, ___, underscore to the file name e.g. SITEA___. Assuming that the previous file name had been the default (EMP400___001), the *Next* file in the sequence would be AREA____002. If the *last* file stored in the system had been EMP400___003, the next file would have been labeled SITEA___. If an additional file was then collected it would be labeled SITEA___003
- The user selects the file name SITE1. The Profiler will ADD a four dash underscore AND the number 001 e.g. SITE1 becomes SITE____001. The *Next* file in the sequence would be SITE____002 and the numbering sequence would have continued.
- The user selects the file name AREA51A. The Profiler software will ADD a one dash _ underscore e.g. AREA51A_., however if the user had named the file AREA51, the Profiler software will add a four dash underscore, ____, AND the number 051. e.g. AREA____051. Spooky isn't it? The *Next* file in the sequence would be AREA____052 and so on.

The default data *.EMI files as well as binary *.DBZ files and *.GPS files (if data is collected with GPS)

Date

This field displays the date and time. This field is ***not*** updated automatically. Prior to beginning data collection, the user can select the Date field. This will update the date and time to its (current) correct value. This field **DOES NOT** affect the date and time written to the data files (*.EMI) or binary files (*.DZB) r the GPS files. These files all have the correct time and date written to them at the start of data collection. When the WAAS GPS is enabled the GGA string is updated at the acquisition rate set for the system. When an external GPS is used the time and date of the GGA string are updated at the output rate of the COM port of the GPS system.

Units

This field displays the linear units that will be used in the Grid Config menu for XMIN, XMAX and YMIN and YMAX grid limit values, as well as the reading Step (in the Stationary mode only) and the transect Spacing. This field will toggle between English and Metric units. When the desired Grid Config has been entered, tap **OK** to return to the Review Parameters menu. (See Setting Grid Config, page 39).

Project Parameters Menu

To access the Project Parameters, select **Review Parameters > Project Parameters** (Figure 53).

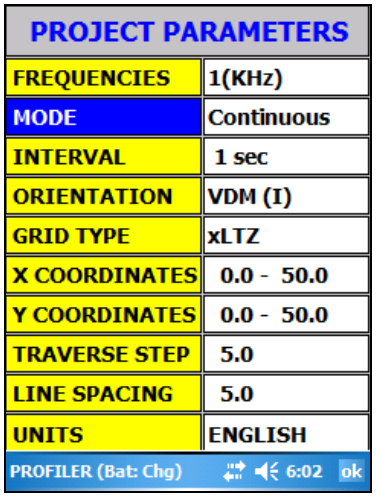


Figure 53: Project Parameters menu.

The Project Parameters screen displays *ALL* of the data acquisition parameters as well as the Grid Configuration parameters selected by the user.

- The Select Parameters menu can be accessed *directly* from this menu by selecting any of the Frequency, Mode, Interval, or Orientation fields. This allows the user to quickly change any acquisition parameters if survey requirements or site conditions change.
- The Grid Config menu can be accessed directly from this menu by selecting the Grid Type, X Coordinates, Y Coordinates, Traverse Step or Line Spacing.

2.9 Save Setup

Once all acquisition parameters have been selected, information on the survey parameters and grid configuration can be saved for easy recall. To escape from the Select Parameters menu tap **OK** on the PDA Status Bar to accept the current data acquisition parameters.

1. The data acquisition setup can be saved by selecting **Main > Save Setup**. Select **Save Setup**.

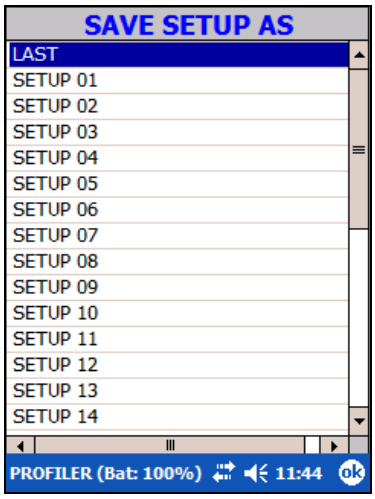


Figure 54: Save Setup menu.

2. The user must select a **Setup Number** location. There are thirty (30) memory locations available to the user to save survey setup parameters. To select a Survey memory location, simply tap on the Survey number and then tap **OK** on the PDA Status Bar to return to the Main menu.

Chapter 3: Collecting Data

3.1 Set Data Display Parameters

Collect Data Menu

The fields in the Collect Data menu allow you to enter the data display parameters of your survey (Figure 55). This menu is accessed by selecting **Main > Collect Data**.

- F_Strength (I) (page 49)
- F_Strength (Q) (page 49)
- Conductivity (page 49)
- Alphanumeric Display (page 49)
- Graphics (page 49)
- Data Display Limits Setup (page 23)
- Start Data Collection (page 50)

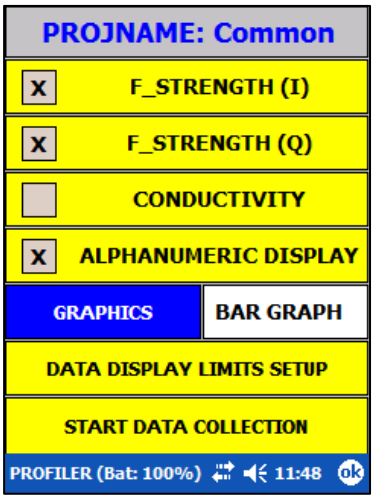


Figure 55: Collect Data Run Time menu.

F_Strength (I)

The magnitude of the In-Phase component of the secondary field. Values are displayed in PPM (Parts per Million). This may value may be displayed simultaneously with F_Strength (Q).

F_Strength (Q)

The magnitude of the quadrature component of the secondary field. Values are displayed in PPM (Parts Per Million). This value may be displayed simultaneously with F_Strength (I).

Conductivity

When displaying the apparent conductivity, both the F_Strength (I) & F_Strength (Q) displays are ***disabled***. When Conductivity is selected, the system will display ***only*** the apparent conductivity (σ_a). **The correct apparent Conductivity can only be displayed if the user has selected 15 kHz as one of the transmit frequencies. (SEE:** Section 2.4 System Calibrations)

Alphanumeric Display

If Alphanumeric is selected, the numeric values of the selected components will be displayed.

Graphics

The Graphics field allows the user to select a Bar Graph or Line Graph display mode. If **None** is selected, the data will be displayed as Alphanumeric values only. When Line Graph or Bar

Graph is selected, the user has the option of displaying Alphanumeric data as well. Data may be displayed in either Linear or Logarithmic scale.

Data Display Limits Setup

For details on Data Display Limits Setup procedure see page 26, section 2.3.

Start Data Collection

When the operator selects Start Data Collection, the EMP-400 will advance to the Data Collection (Run-Time) menu, as detailed below in Section 3.2, Data Collection.

3.2 Data Collection

1. After entering the desired Display Parameters, F_Strength (I) and/or F_Strength (Q) or Conductivity, select **Start Data Collection**. The system will now display either the Data or the Positioning display (see Section 2.4 Check System Diagnostics Parameters, Display Preferences).

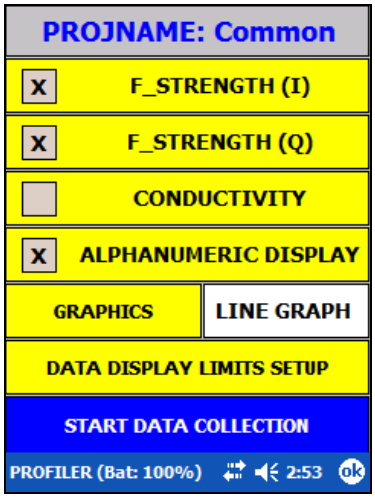


Figure 56: Start Data collection.

2. When data collection is first initiated, the data display field will remain blank until the user presses the **Enter** button on the PDA keypad, or the **Start** button on the key fob. The system will begin data collection, after a 1-second pause. This pause before the start of data collection occurs **only** on the first line of a survey.

3. Once the first line has been collected, data collection will begin immediately after the user restarts data acquisition with the Continue Data Collection command located in the Run Time menu (Figure 60). Figure 57 illustrates the Data Collection Data display. In this case, the user has selected a Line Graph display along with an alphanumeric data display.

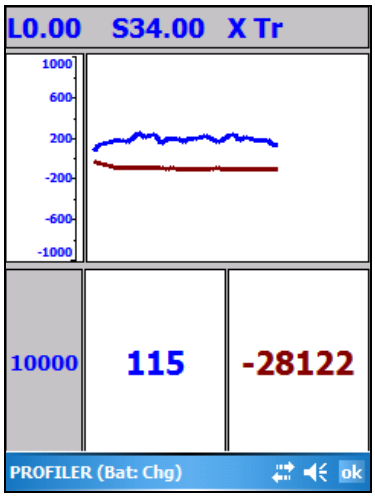


Figure 57: Line Graph with Alphanumeric data.

- Note that the In-Phase data for the alphanumeric display is on the *left* and the Quadrature data is on the *right*. The transmit frequencies are listed in the left-most column starting with Freq 1, Freq 2, Freq 3, etc. The transmit frequencies are listed in the sequence in which they were entered. In this example of one frequency data collection, Freq 1 is 10 kHz. The colors selected for the components displayed in the line graph display correspond to the colors of the components in the alphanumeric display.
- Figure 58 illustrates a bar graph display with alphanumeric display. This is an example of two frequency data collection. As with the line graph display, the colors selected for the components displayed in the bar graph display correspond to the colors of the components in the alphanumeric display.

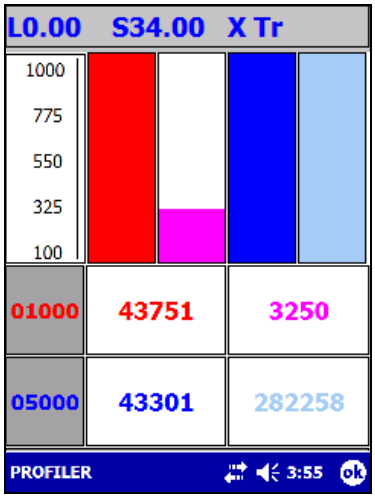


Figure 58: Bar Graph with Alphanumeric display.

Note that the In-Phase data for the bar graph and alphanumeric display is on the *left* and the Quadrature data is on the *right*. You will note that the In-Phase for 1 kHz data is saturated, as well as both the In-Phase and Quadrature for 5 kHz data. In this situation, it may be desirable to return to the Data Display Limits Setup to reset the Lower and Upper bounds for the data display so that the Bar Graph data display does not saturate, or set the Scale Type to Logarithmic.

4. Once data collection is initiated, the user then proceeds along the survey transect. The user can toggle between the Data display (above) and the Positioning display (below) by tapping with the stylus anywhere in the data display field.

- If fiducial marks are placed in the data, they will be drawn as red dots on the positioning display. Note that in this example some of the mark positions are misaligned or misplaced. This is due to the user entering a mark before or after a survey station or at a line end.

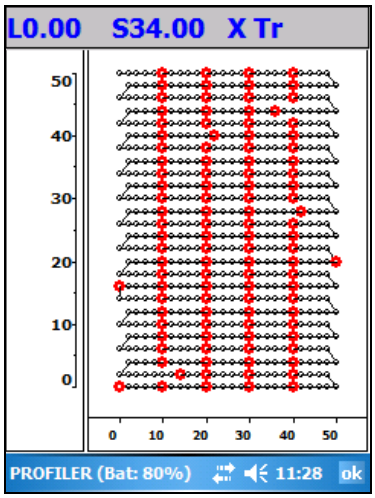


Figure 59: Positioning display with fiducial marks indicated.

- By toggling between the Data Display and the Positioning display, the user can assure that data is being collected with the marks in the correct positions and can also evaluate differences in line lengths (the samples per transect) when collecting data in the Continuous mode.

Pause Data Collection

In order to skip a station due to the presence of a surface obstacle, or to skip a transect due to the presence of a large surface feature, the user should select **OK** from the Data display or Positioning display, or press **OK** on the PDA key pad (or depress the RF Start/Stop key fob key twice). Data acquisition will be paused, and the Run Time menu will be displayed (Figure 60).

Run-Time Menu

When data collection is paused, the user has the option to:

- Advance To New Line (page 53)
- Delete Current Line (page 53)
- Skip Station (page 54)
- Delete Last Station (page 54)
- Continue Data Collection (page 54)
- Stop Data Collection (page 54)

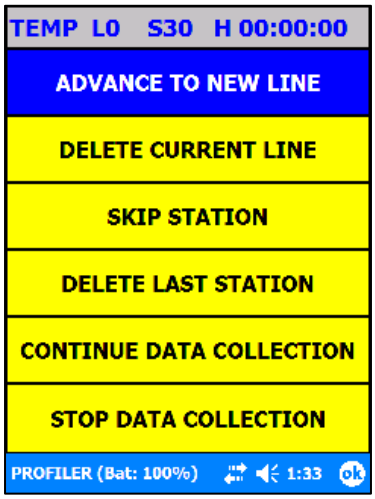


Figure 60: Run-time menu.

Advance To New Line

If this option is selected, the line counter at the top of the screen would increment/decrement depending upon the grid type selected.

Delete Current Line

If this option is selected, the entire current line would be deleted from memory and the line counter and station counter would increment/decrement to its previous value depending upon the grid type selected. This process can be repeated to the beginning of the survey. Any deleted lines would then have to be surveyed again in the direction specified by the operator in the Grid Type menu.

Note: In order to prevent the inadvertent deletion of survey lines, the EMP-400 software will prompt the user with a courtesy check prior to deleting a survey line (Figure 61).

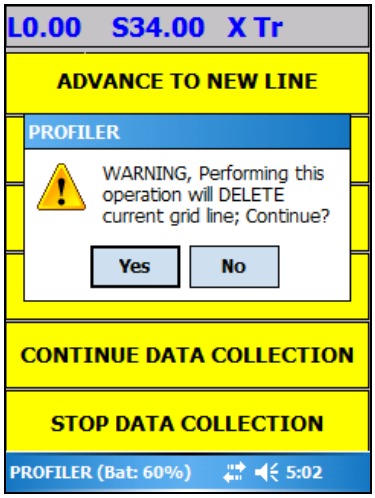


Figure 61: Run-time menu - Delete Line Courtesy Check.

Skip Station

If this option is selected, the station counter will increment/decrement with each tap of the PDA stylus in this field. This function can be repeated as many times as is necessary, however the number of skipped stations cannot exceed the value entered for XMAX or YMAX in the Grid Config menu (depending on which type of traverse, X or Y is being collected).

Delete Last Station

If this option is selected, the last recorded reading will be deleted from memory. In this instance, the station counter would decrement/increment to the previous station (based on the Step setting and the Grid type in the Grid Config menu). This function can be repeated, as many times as necessary, however the number of deleted stations cannot exceed the value entered for XMIN or YMIN in the Grid Config menu.

Continue Data Collection

If this option is selected, the system will continue in data collection mode until data collection is paused at the end of the survey transect.

- As indicated above, data collection can be paused in *one of two ways***.** The user can select **OK** on the PDA keypad or the user can use the RF key fob to pause data collection by depressing the Start/Stop key twice.
- If the current survey line is then terminated by selecting Advance To New Line, the line counter at the top of the screen will increment/decrement and the station counter will reset to its appropriate start value (depending upon the Transect Spacing, Step Spacing and grid type selected in the Grid Config menu). The user would then select Continue Data Collection from the Collect Data menu, or depress the RF key fob Start key once.
- If intermediate survey control points were marked out during the survey grid set up phase, and the operator wishes to mark these locations, the operator can use the RF key fob to enter fiduciary marks into the data file by depressing the Upper RF key fob button once or by pressing the **Enter** (↵) key on the PDA keypad.

Stop Data Collection

1. Once the survey grid has been collected, the user should do one of the following to stop data collection and return the PDA to the Data Collection menu (Figure 62).

- Select **OK** from the PDA key pad, or
- Depress the RF key fob **Start/Stop** key twice.

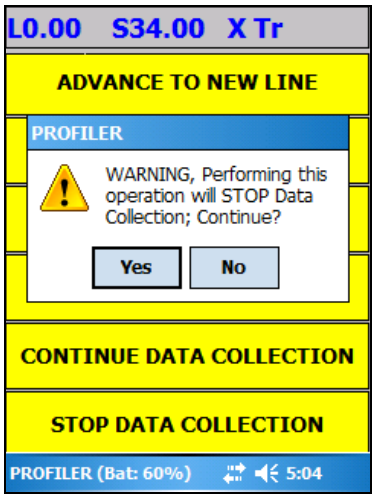


Figure 62: Run-time menu - Stop Data Collection Courtesy Check.

2. The EMP-400 software will prompt the user with a courtesy check to ensure that the user does wish to terminate data collection (Figure 62).

- If the user wishes to terminate data collection, tap Yes with the PDA stylus.
- If the Stop Data Collection key was selected in error, or the user wishes to continue data collection, tap **No**. The user may tap **Continue Data Collection**.

3. If **Yes** was selected by the user to Stop data collection, the Saving Data progress screen will be displayed (Figure 63).

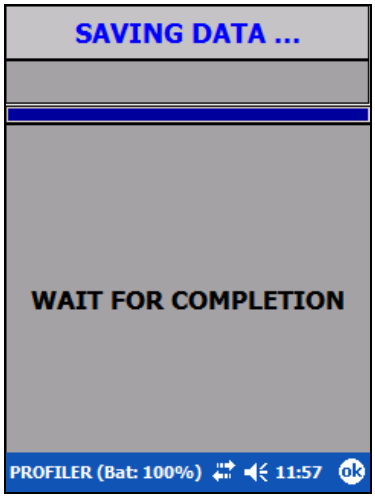


Figure 63: Saving Data progress display.

4. Once the system has completed saving the file, the PDA will sound a tone and the system will return to the Main menu. The system software is designed to increment file numbers starting from the file number designated in the Next File field in Main >Review Parameters > Project Info(Figure 64). (See also: Chapter 3, Section 3.5 and Figure 52: Project Information Menu Display).

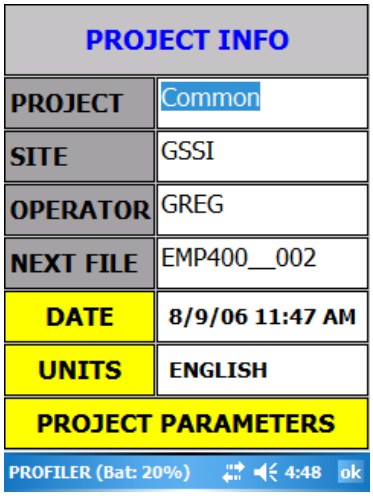


Figure 64: Project Info menu - Next File.

Note: Under certain conditions the EMP-400 Bluetooth communications may be lost or interrupted. When communication is lost during data collection or during the File Save process, the system will not automatically increment the File Number to the next file. In such instances, it is **most important** that the user return to the Project Info menu display and select the Next File field to increment the next file number. (change all for file recovery)

The user should check the working directory after a Bluetooth communications interrupt to ascertain exactly what file numbers have been saved and what the last saved file number was. If this check/correction is not performed, the user may find that there is a break in the file number sequence within the working directory e.g. the files may be numbered: EMP400___001, EMP400___002, EMP400___003, EMP__005.

3.3 Data Review

Review Data Menu

The Review Data menu (Figure 65) allows the user to review, delete or quick contour data. Select **Main > Review Data**.

- Project (page 57)
- File (page 57)
- Review Last File (page 58)
- Review (page 58)
- Delete Projects (page 59)
- Delete Files (page 60)
- Recover Last File (page 61)

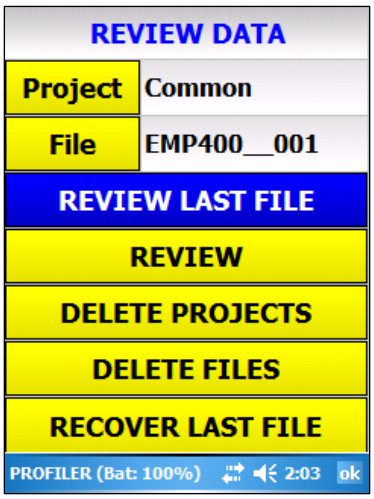


Figure 65: Review Data menu.

Project

The Review Data menu allows the user to display quick contour maps of an entire data grid.

1. To select the appropriate Project folder, tap **Project**. The PDA will then display the stored project folders (Figure 66).

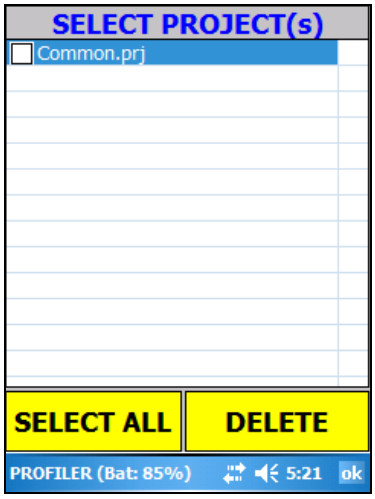


Figure 66: Select Project Folder menu.

2. Select the Project in which the file to be reviewed resides. Note: Common.prj is the default EMP-400 project directory. Once the desired Project has been selected, the project name will appear in the Project field.

File

3. The user can then select the desired file(s). Tap **File** and select the desired file name (Figure 67) to Review the file.

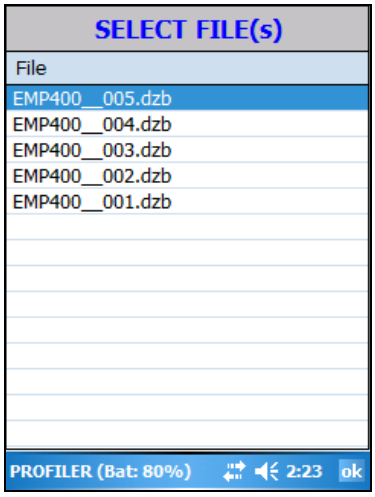


Figure 67: Select File(s) menu.

Review Last File / Review

4. Once a file has been selected, using either the File, Project>File or Review functions, the Select Data Value screen will be displayed (Figure 68).

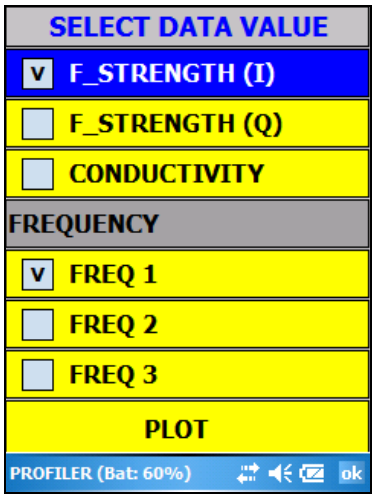


Figure 68: Select Data Value menu.

5. From this screen, the operator can select the frequency and the specific component of that frequency to be displayed as a contour map. The EMP-400 contouring algorithm is very simple and uses a triangular nearest-neighbor method to grid and contour the data. This function serves as a quick way to review your acquired data in the field.

Example: The user can select the transmit frequency, FREQ 1 through FREQ 3, and F_Strength for either the In-Phase or Quadrature components, or Conductivity, and then select **Plot**. The system will now generate a contour plot (Figure 69).

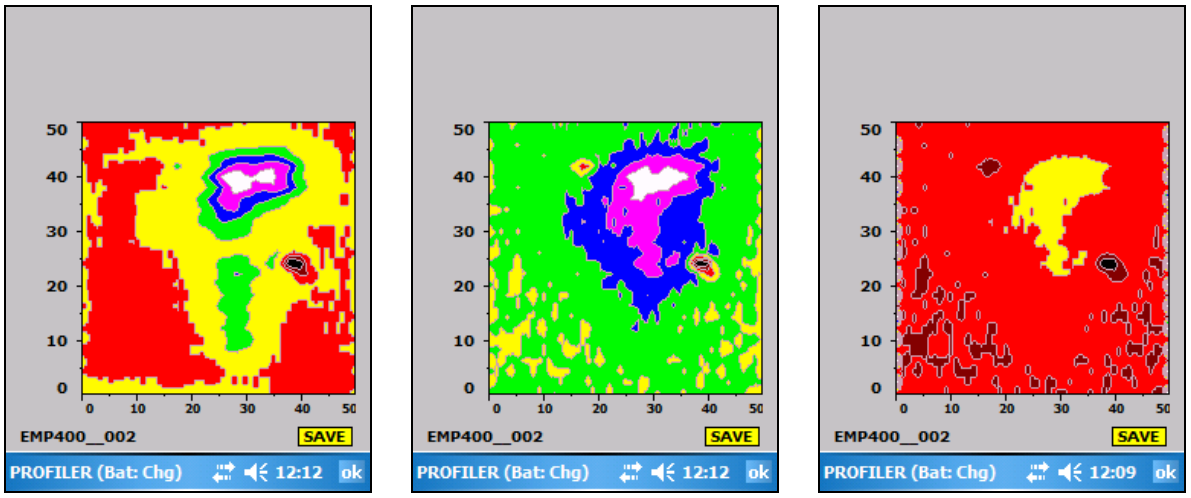


Figure 69: Review Data Contour Plot In-Phase (left), Quadrature (center) and Conductivity (right).

The user will note that the display provides no contour level information. This display is designed to provide the operator with a quick look at the data in the field in order to identify possible features of interest. The user can change the contour level colors and contour type by

tapping on the display with the PDA stylus. This will switch the display to the Color Map Tables menu (Figure 70).

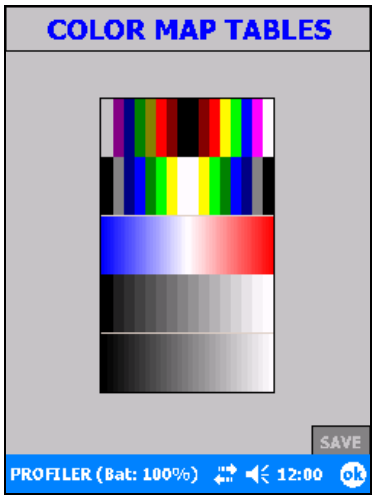


Figure 70: Contour Plot Color Map Table.

- There are five (5) system defined Color Tables. These are displayed horizontally on Color Map Tables menu as five separate color bands:
    - 2 - 16-shade color tables (top)
    - 1 - 256-shade color table (blue, white, red-middle)
    - 1 – 16-shade grayscale (second from bottom)
    - 1 – 2560shade grayscale (bottom)
- Tap on the desired color table and then tap **OK** from the PDA status bar**,** the screen will switch back to the contour map display and the data will be displayed with the new user-selected color table.
- To save the quick contour map as an *.bmp file, tap **Save** in the bottom right corner of the Review Data Contour Plot display. This file will be written into the active Project folder.

Delete Projects

To delete a project folder select **Review Data > Delete Projects** (Figure 71). The user can delete single projects by selecting the box next to the project to be deleted, or the user can **Select All** and all of the projects in the user memory will be deleted.

Note: Projects can also be deleted by connecting the PDA to your PC via ActiveSync and deleting the appropriate Project folder from the Profiler\Data directory.

Note: There is **NO** user protection in this menu display. The system will **NOT** prompt the user with a ***Confirmation Warning*** when deleting projects**.**

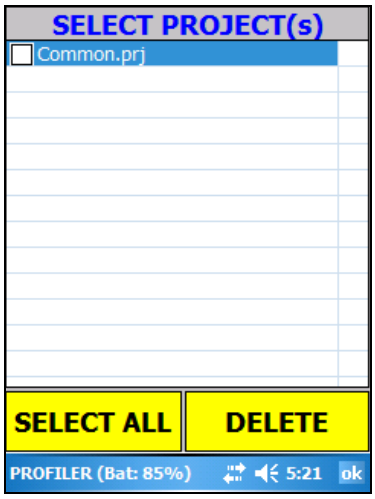


Figure 71: Delete Project(s) menu.

Delete Files

To delete a file, groups of files, or an entire directory of files, select **Review Data > Delete Files**. The Delete File menu display will appear (Figure 72).

- To delete a single file, select the box next to the file to be deleted, and then tap Delete.
- To delete groups of files (Figure 72), select the boxes next to the files to be deleted, and then tap Delete.
- To delete all of the files, select **Select All**, and all of the files in the current working project folder will be deleted when **Delete** is tapped.

Note: Files can also be deleted by connecting the PDA to your PC via ActiveSync, selecting the appropriate Project folder and deleting the appropriate files from the folder.

Note: There is **NO** user protection in this menu display. The system will **NOT** prompt the user with a ***Confirmation Warning*** when deleting files.

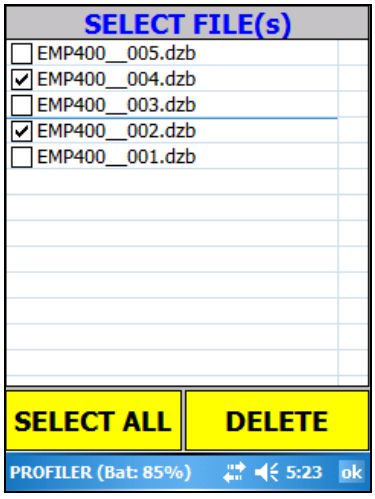


Figure 72: Delete File menu.

Recover Last File

In the case of loss of power to the PDA, or loss of the PDA Bluetooth™ communications with the Profiler during data collection, this function enables the user to recover the last file collected at the time of power interruption or communications loss.

1. To recover the file the user should follow the system power on procured as outlined in Section 2.1 Starting the EMP-400.
2. The user should then go to the Diagnostic menu and select **Recover Last File**.
3. The system will prompt the user with a courtesy check. If you wish to recover the file, select **Yes** and the system will restore the file up to the point at which the system faulted (Figure ??).

- It is important to note that if the user wishes to continue data collection at the point where the system faulted, the user will have to enter the Grid Coordinates of the LAST data point collected and start a new file.

3.4 Shutting Down the System

To shut down the data collection interface after you have completed your survey, return to the Main menu, and tap **OK** on the PDA status bar. The system will then display the program exit screen (Figure 73).

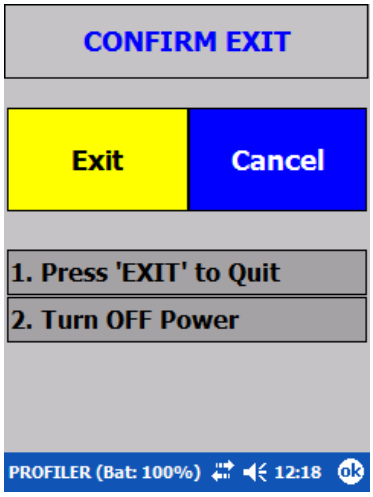


Figure 73: Profiler Program Exit.

To escape from the program tap **Exit**. If you selected **OK** on the PDA status bar inadvertently, while in the Main menu, tap **Cancel** and the system will return you to the Main menu.

Chapter 4: Transferring, Converting and Exporting EMP-400 Data

Once you have collected your EMP-400 data you will need to transfer the files from the PDA to your laptop or desktop computer for conversion, editing, formatting and display. The TDS RECON-400 PDA utilizes a USB connection and Microsoft® ActiveSync to transfer data to and from the PDA. The user must have ActiveSync version 4.1.0 (or higher) installed on your computer and/or the Profiler File Transfer Utility program.

If you do not have ActiveSync installed on your computer, you can download it from the following URL: http://www.microsoft.com/windowsmobile/activesync/default.mspx. You should also have installed the MagMap2000 software which was supplied with your system. Additional 3rd party software such as ArcheoSurveyor, GEOSOFT, or SURFER are commonly used for data processing, and the gridding and contouring of EM data.

4.1 Transferring Data

1. To transfer data, the user must first connect the USB cable supplied with your EMP-400 to the PDA.
2. The USB cable has a flat "A" type USB connector and a square "B" type connector. The square "B" end should be plugged into the USB port on your PDA (Figure 74).

Figure 74: USB "B" connector plugged into PDA USB port.

3. The user should now plug the flat USB type "A" connector into a free USB port on your PC (Figure 75).

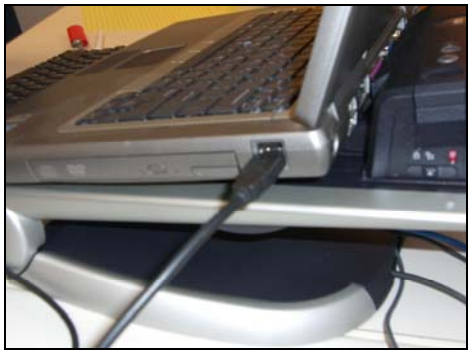


Figure 75: USB "A" connector plugged into free PC USB port.

4. Data can be transferred directly from the PDA to your computer via ActiveSync, or you can use Profiler File Transfer Program/File Transfer Utility interface. The File Transfer Utility interface is designed to access the EMP-400 storage memory.

Note: It is necessary to install ActiveSync in order for the File Transfer Utility to function correctly.

4.2 Transferring Data Using ActiveSync

1. Upon connection of your PDA to your computer, you will hear the ActiveSync connection tone and the Synchronization Setup Wizard window will appear (Figure 76).

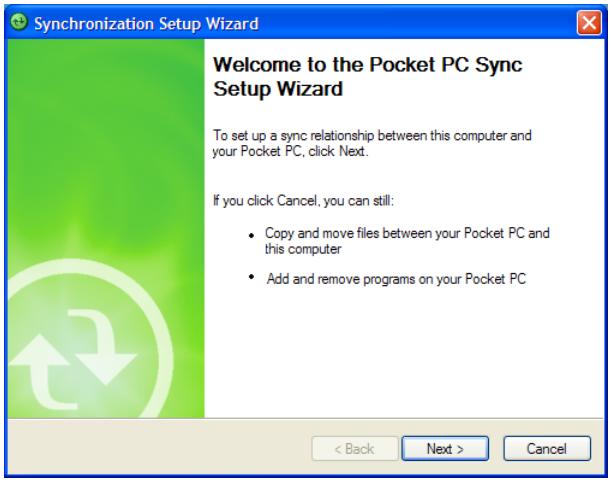

Synchronization Setup Wizard
Welcome to the Pocket PC Sync Setup Wizard
To set up a sync relationship between this computer and your Pocket PC, click Next.
If you click Cancel, you can still:
Copy and move files between your Pocket PC and this computer
Add and remove programs on your Pocket PC
< Back
Next >
Cancel

Figure 76: Synchronization Setup Wizard.

2. As we are not setting up a sync relationship between the PDA and the PC, the user should select **Cancel**. ActiveSync will then connect the PDA and PC and the ActiveSync connection window will appear (Figure 77).

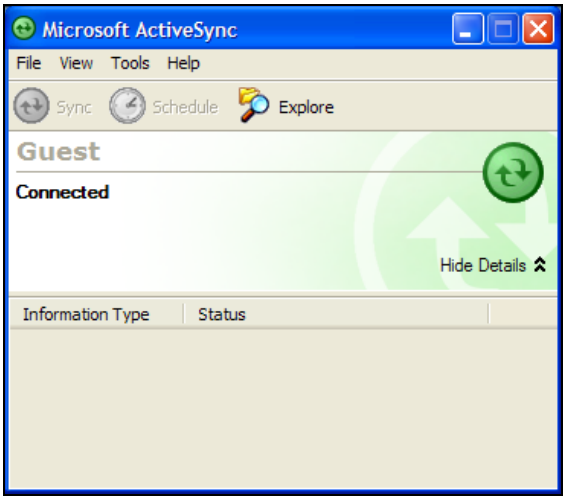


Figure 77: ActiveSync Explorer Connection window.

3. To access the PDA system and memory, select the **Explore** icon. This will access the Mobile Device window (Figure 78).

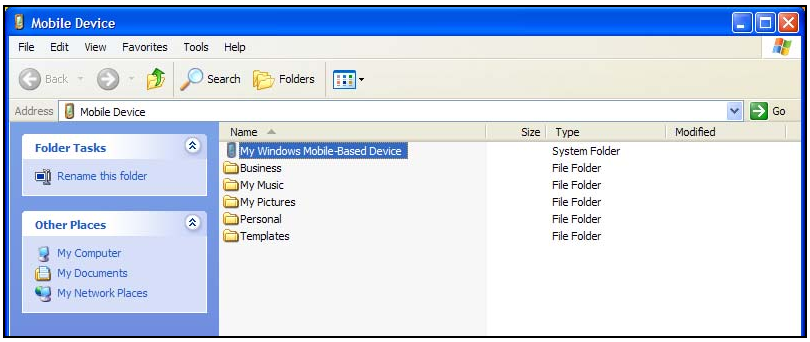


Figure 78: Mobile device window.

4. The user should now select the **My Windows Mobile-Based Device** icon. This will access the PDA Root directory (Figure 79).

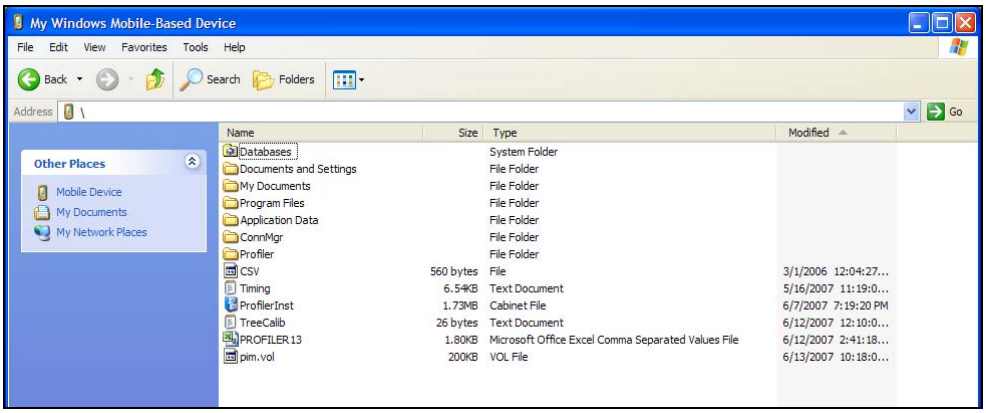

My Windows Mobile-Based Device
File Edit View Favorites Tools Help
Back Search Folders
Address \
Go
Other Places
Mobile Device
My Documents
My Network Places
Name Size Type Modified
Databases System Folder
Documents and Settings File Folder
My Documents File Folder
Program Files File Folder
Application Data File Folder
ConnMgr File Folder
Profiler File Folder
CSV 560 bytes File 3/1/2006 12:04:27...
Timing 6.54KB Text Document 5/16/2007 11:19:0...
ProfilerInst 1.73MB Cabinet File 6/7/2007 7:19:20 PM
TreeCalib 26 bytes Text Document 6/12/2007 12:10:0...
PROFILER 13 1.80KB Microsoft Office Excel Comma Separated Values File 6/12/2007 2:41:18...
pim.vol 200KB VOL File 6/13/2007 10:18:0...

Figure 79: Mobile-device root directory window.

5. The user should now select the **Profiler** folder. This will access the Data directory (Figure 80).

Note: Do not access and files or directories in the PDA root directory other than the Profiler file folder. Some files in the PDA root directory are required system files or log files. These files should not be accessed, moved or deleted from the PDA root directory. GSSI assumes no responsibility for the proper operation of the EMP-400 if any of these files have been accessed, moved or deleted.

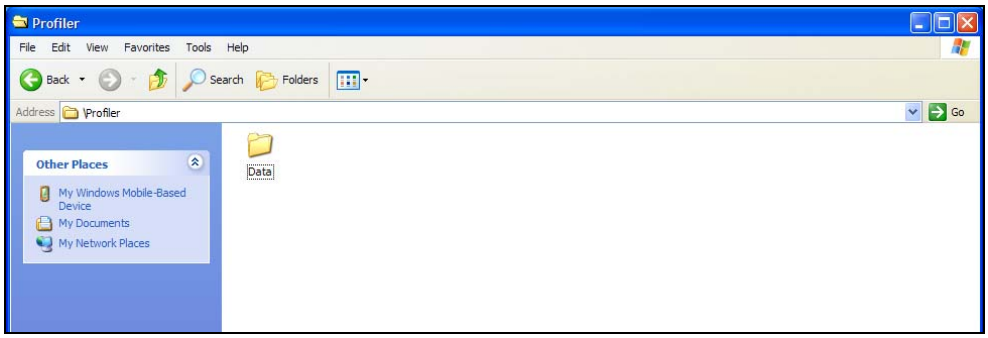


Figure 80: Profiler Data directory window.

6. The user should now select the **Data** folder (Figure 81). This example folder contains the following files/folders: Common.prj (the default Project folder) and Setup01.SRV. This file and project folders should be moved or deleted by the operator. GSSI assumes no responsibility for the proper operation of the EMP-400 if any of these files have been accessed, moved or deleted.

- All project folders, including those created by the user, will be found in the PROFILER\Data folder and are identified by the extension *.prj.

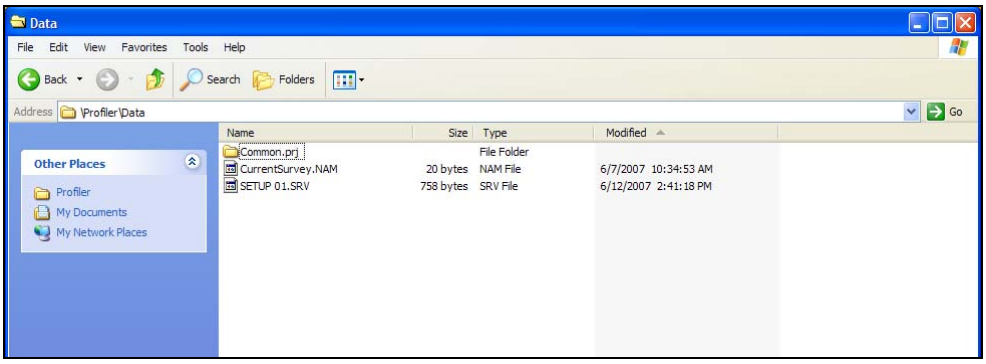


Figure 81: Profiler data directory.

7. If the user has not created a custom project directory, all of the EMP-400 data files will be found in the Common directory. Select the **Common.prj** folder. An example of the Common project folder contents are illustrated in Figure 82.

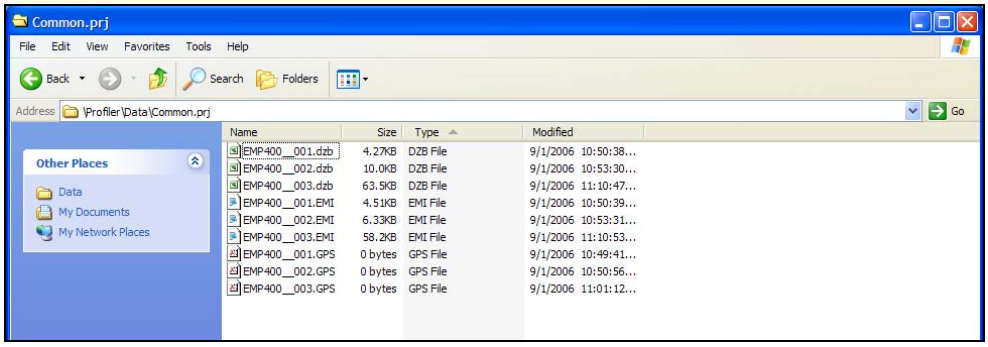

Common.prj
File Edit View Favorites Tools Help
Back Search Folders
Address \Profiler\Data\Common.prj
Go
Other Places
Data
My Documents
My Network Places
Name Size Type Modified
EMP400__001.dzb 4.27KB DZB File 9/1/2006 10:50:38...
EMP400__002.dzb 10.0KB DZB File 9/1/2006 10:53:30...
EMP400__003.dzb 63.5KB DZB File 9/1/2006 11:10:47...
EMP400__001.EMI 4.51KB EMI File 9/1/2006 10:50:39...
EMP400__002.EMI 6.33KB EMI File 9/1/2006 10:53:31...
EMP400__003.EMI 58.2KB EMI File 9/1/2006 11:10:53...
EMP400__001.GPS 0 bytes GPS File 9/1/2006 10:49:41...
EMP400__002.GPS 0 bytes GPS File 9/1/2006 10:50:56...
EMP400__003.GPS 0 bytes GPS File 9/1/2006 11:01:12...

Figure 82: Profiler data file types.

The user will note there are three (3) files types:

EMP400___00#.dzb – This is a binary bitmap contour map file of the survey grid collected. This files is used to create the Review Data contour map. This file can also be displayed in the 3D Mode in the GSSI GPR data processing program, RADAN™.

EMP400___00#.EMI – This is the binary data file stored by the EMP-400. It is converted to an ASCII text type file upon transfer from the PDA. It may be opened in EXCEL as a comma separated variable file (CSV) file. It is suggested that EXCEL be used only to review the .EMI data file. If it is necessary to edit the file, GSSI recommends that the file first be converted to an *.dat file in the MagMap program. This file can then be opened and edited in MapMap 2000 or Surfer. After any edits are made, the operator must remember to save the file as an *.dat file type.

The *.EMI file is recognized by MagMap2000 as a native file type. MagMap2000 has been modified to read the EMP400 file header. MagMap 2000 will automatically perform linear interpolation on data collected with the EMP-400 in the Continuous mode. An example EMP400___00#.EMI file is illustrated in Figure 83.

EMP400___00#.GPS – This is the GPS file required by MagMap2000 to integrate the GPS and EM data. It is formatted as a standard NMEA GGA string. The can be opened in Excel as a comma delimited file. A GPS file is stored by the system if the WAAS GPS is enabled or the user has connected an external GPS unit to the PDA (see Section 2.2: Check System Diagnostic Parameters).

Figure 83 is an example of a multi frequency file collected without a GPS system connected to the PDA. All of the data acquisition and grid parameter information is written as a header above the EMP400/GPS data. The header is separated from the data section of the file by the $$$ signs.

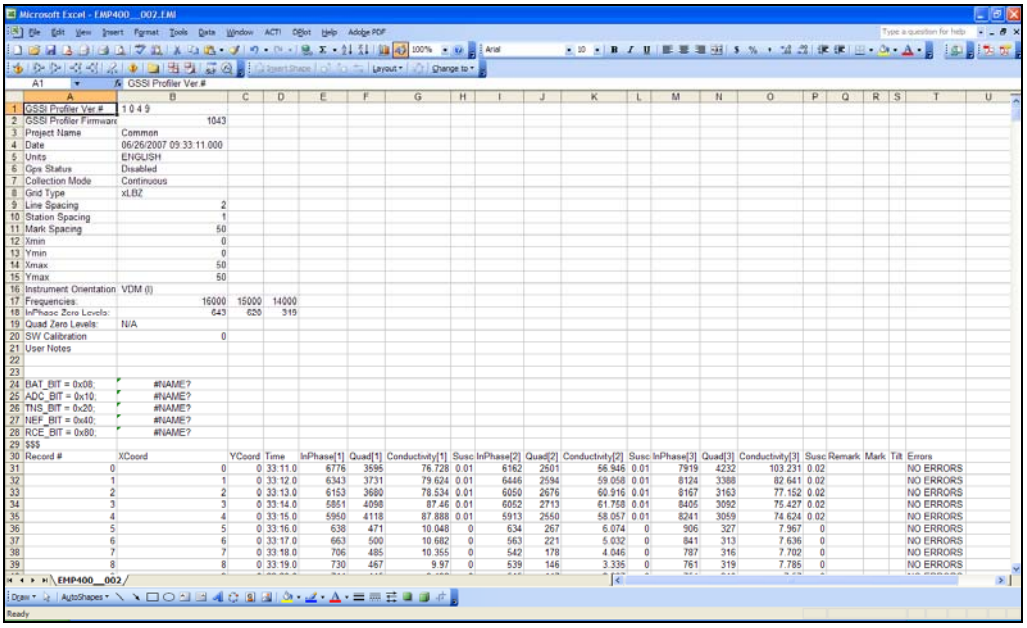


Figure 83: Profiler *.EMI data file example.

Figure 84 is an example of a multi frequency file collected with a GPS system connected to the PDA via the comm port. All of the data acquisition and grid parameter information is written as a header above the EMP400/GPS data. The header is separated from the data section of the file by the $$$ signs. The GPS information, latitude, longitude and elevation (ALT), is written inside the EMI file. In this example they are found in columns S, T and U.

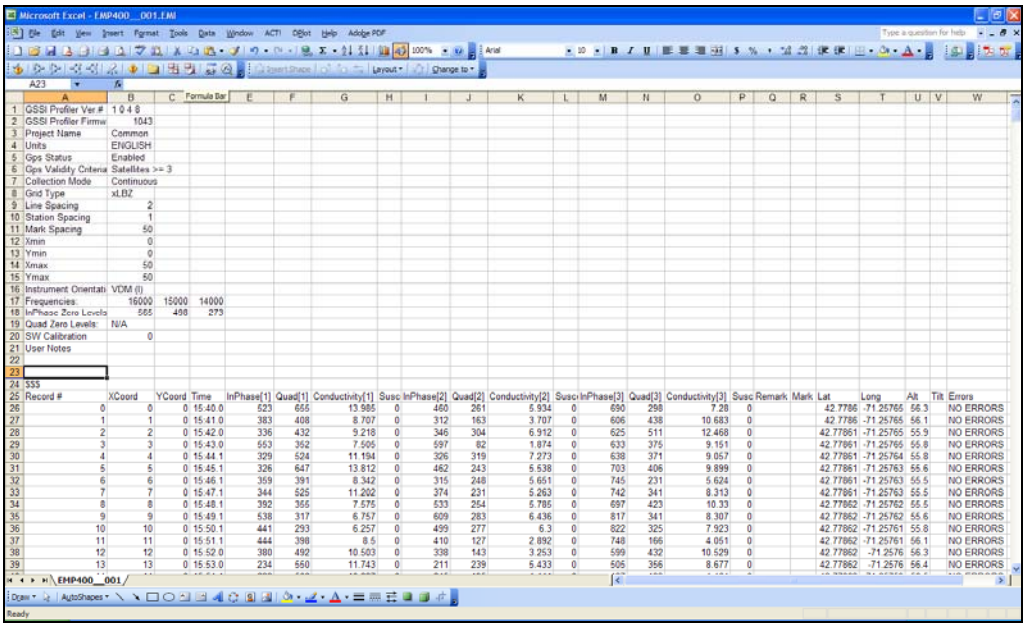


Figure 84: Profiler *.EMI data file with GPS.

Figure 85 illustrates the standard EMP-400 GPS file. The format of all EMP-400 GPS files are in standard NMEA GGA format.

This file is compatible with the MagMap2000 GPS Conversion and Processing functions. It can also be translated to other co-ordinate types by the user with the appropriate formulas in Microsoft Excel™.

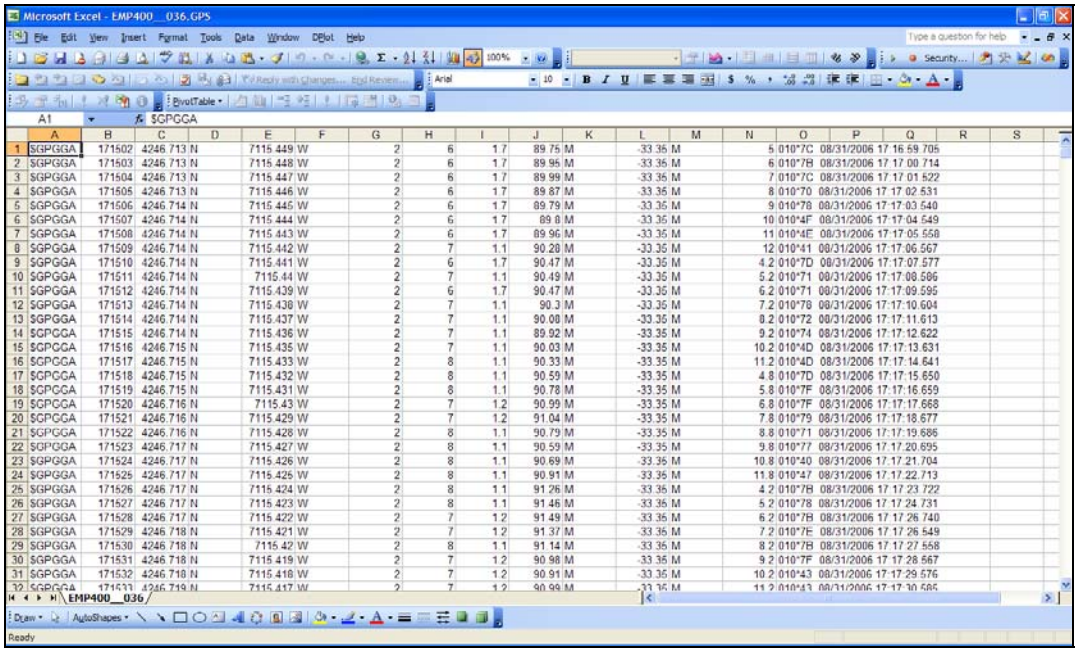


Figure 85: Profiler GGA *.GPS data file example.

The **EMP400___00#.dzb** file type is a two dimensional binary bitmap. It is used to generate the contour map display in the Review Data menu of the EMP-400 PDA (Figure 69). It is also compatible with the 3D display of RADAN.

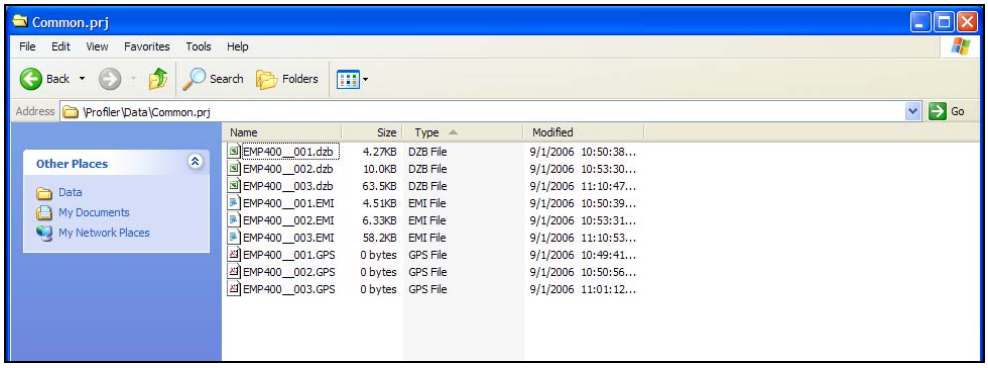

Common.prj
File Edit View Favorites Tools Help
Back Search Folders
Address \Profiler\Data\Common.prj
Go
Other Places
Data
My Documents
My Network Places
Name Size Type Modified
EMP400__001.dzb 4.27KB DZB File 9/1/2006 10:50:38...
EMP400__002.dzb 10.0KB DZB File 9/1/2006 10:53:30...
EMP400__003.dzb 63.5KB DZB File 9/1/2006 11:10:47...
EMP400__001.EMI 4.51KB EMI File 9/1/2006 10:50:39...
EMP400__002.EMI 6.33KB EMI File 9/1/2006 10:53:31...
EMP400__003.EMI 58.2KB EMI File 9/1/2006 11:10:53...
EMP400__001.GPS 0 bytes GPS File 9/1/2006 10:49:41...
EMP400__002.GPS 0 bytes GPS File 9/1/2006 10:50:56...
EMP400__003.GPS 0 bytes GPS File 9/1/2006 11:01:12...

Figure 86: Profiler data files.

Prior to transferring data to the PC, the user should create a destination folder for the data. Once the folder has been created on the PC, the user simply has to use the Windows copy, paste, or move functions to copy or move data from the PDA to the destination folder on the PC.

4.3 Transferring Data Using File Transfer Utility

Data can also be transferred from the PDA to PC by using the Profiler Transfer Utility. As indicated, the File Transfer Utility requires that ActiveSync be installed on the PC and the PDA

1. The File Transfer Utility can be copied directly from the Accessories CD provided with your EMP-400 to your PC desktop. Double-click the File Manager desktop icon. The File Manger screen will be displayed (Figure 87).

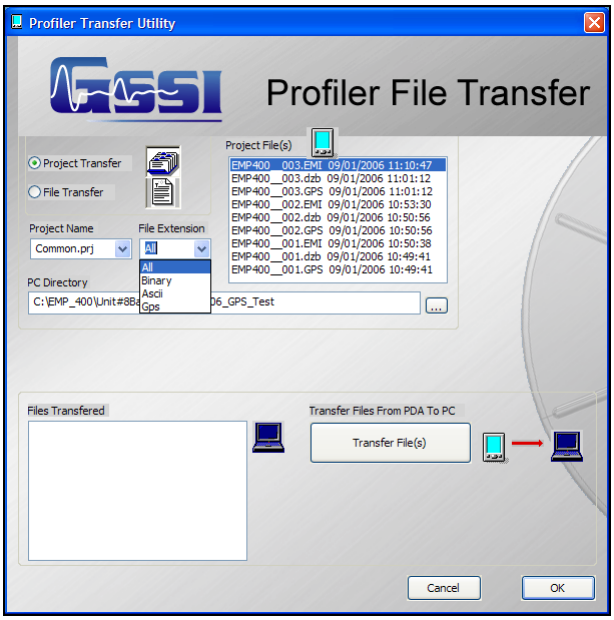


Figure 87: Profiler File Transfer Utility screen.

2. The File Transfer Utility enables the user to transfer single files, groups of files, entire project folders and/or specific file types e.g. binary *.dzb files, ASCII *.EMI files or *.GPS files.

- The **Project Transfer** button allows the user to transfer complete project folders (*.prj) from the PDA to the PC.
- The **File Transfer** button allows the user to transfer selected files (*.EMI, *.GPS or *.DZB) from the PDA to the PC.
- The **PC Directory** button allows the user to select the target directory for the files to be transferred from the PDA to the PC.

3. Once the desired file/project and target directory selections have been made, select **Transfer Files from PDA To PC**. The transferred files will appear in the Files Transferred Window.

4.4 Converting Files in MagMap2000

The MagMap2000 program is provided with the Profiler EMP-400 for two principal purposes:

1. To perform linear interpolation of survey line data collected in the Continuous mode, and to allow the user to edit survey lines, survey points and marker positions using the grid editing commands available in MagMap2000.
2. To integrate GGA GPS data with EMP-400 data.

Converting and Exporting EMP-400 EM Files

1. Once you have transferred your EMP-400 files to your computer, open MagMap2000 by clicking the MagMap2000 icon located on your desktop.
2. To open an *.EMI file, select the file **Open** tab from the Main menu. Using the **Look In Directory** search bar, select the directory to which you transferred your EMP-400I files.

- Upon first opening the program, the user may have to select the **Files of Type** box located at the bottom of the File Open dialog box, and select the GSSI Profiler (*.EMI) file type. The system will now recognize the *.EMI files (Figure 88).

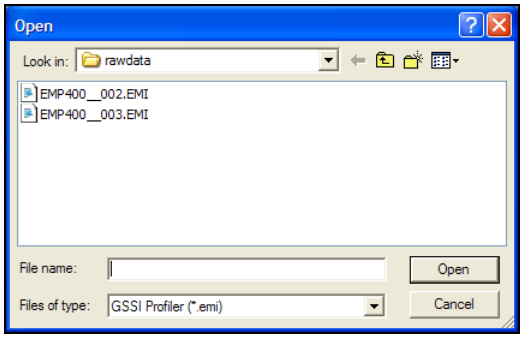


Figure 88: MagMap2000 File Open dialog box.

3. Once you have selected the *.EMI file type, the File Open dialog box should display a list of your EMP-400 *.EMI files. To open a file, select the file with your cursor and click Open, or simply double-click on the desired file.

4. Upon opening the file, the MagMap2000 program will open the GSSI Profiler Information display. This is information comprises data stored in the file header (Figure 89).

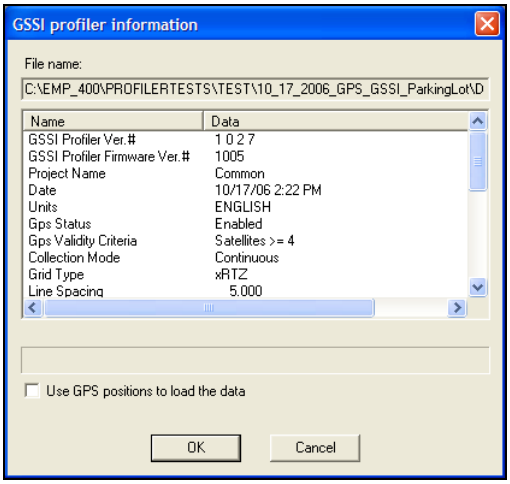


Figure 89: MagMap2000 GSSI Profiler Header Information Display(NEW).

5. If you are satisfied that the information in the file header is correct, particularly the information on the acquired frequencies, orientation and grid parameters, select **OK**.

- If the data was collected in Continuous mode, MagMap2000 will read the information in the file header regarding grid origin location, grid type, X and Y origin location, transect spacing and mark spacing and will generate an ***interpolated*** grid of the collected data.
- If marks (user or fiducial) are present in the data, MagMap2000 will interpolate between the line start mark, the user fiducial marks and the line end mark.
- It is important that the user has entered the correct value for the Marker Spacing in the Grid Config menu. If the user is not placing fiducial marks in the record, the user should enter a value for Mark Spacing that is equal to the transect distance in order for MagMap2000 to interpolate the distances between the recorded readings correctly. In the following example the data file is an xLBZ grid with X and Y origin at zero, and an X and Y maximum of 50. The Step is set to one (1) and the Line Spacing has been set to two (2). The distance between the marks has been set at 50 (the line length). This interpolated grid is illustrated in Figure 90.

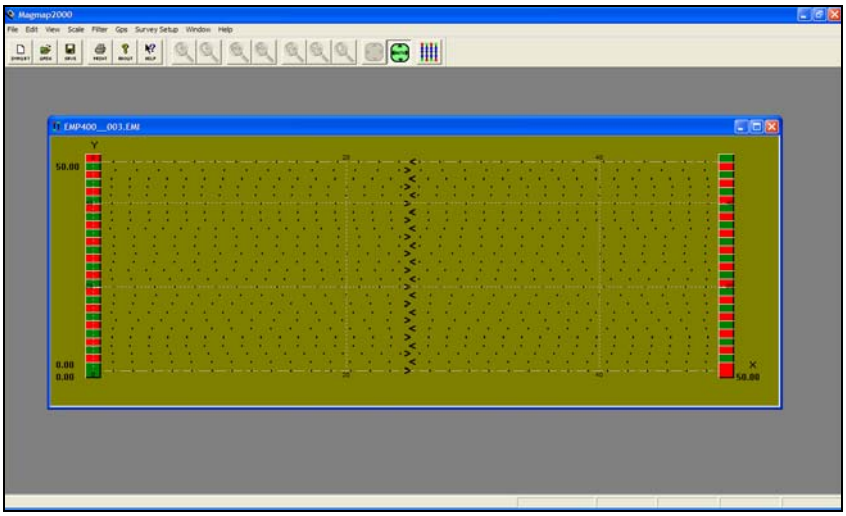


Figure 90: MagMap2000 *.EMI File Grid Display.

In this figure, the **green** squares correspond to the beginning of each transect, the **red** squares correspond to the end of each transect. The location of each data point is indicated by a dot (•) and the direction in which each transect was collected in is indicated by a > or a < arrow. The origin coordinates 0.00, 0.00 and the line end coordinates **X** = 50.00, **Y** = 50.00 correspond to the grid limits for this example grid.

6. The file is now ready to be exported. From the MagMap2000 Main menu toolbar, select **File > Export**. This will bring up the Export Setting dialog box (Figure 91).

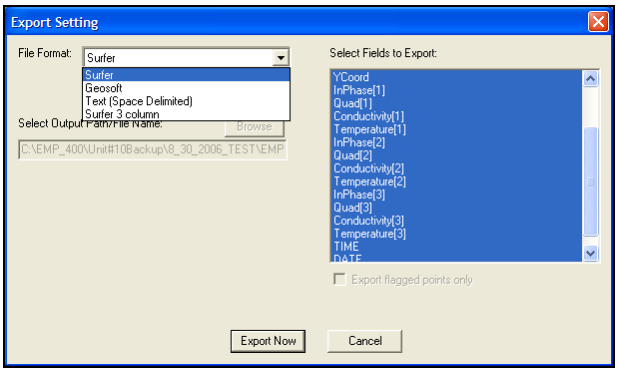


Figure 91; MagMap2000 File Header display.

7. The file can currently be exported in SURFER, GEOSOFT, TEXT (Space Delimited) and SURFER 3 column (X, Y, Z) data file formats. The converted file will be created and can be written back into the directory of your choice by using the Select Output Path/File Name tab. After designating a file name and the target directory for the export file, select **Export Now**. In this example (Figure 91) we have chosen a SURFER*.dat file type.

8. This interpolated file is now ready to be gridded and contoured. This example data file shows interpolated X (position) data in column A and Y (line) data in column B for the positions of each data point. Figure 92 illustrates an interpolated and converted SURFER *.dat file type.

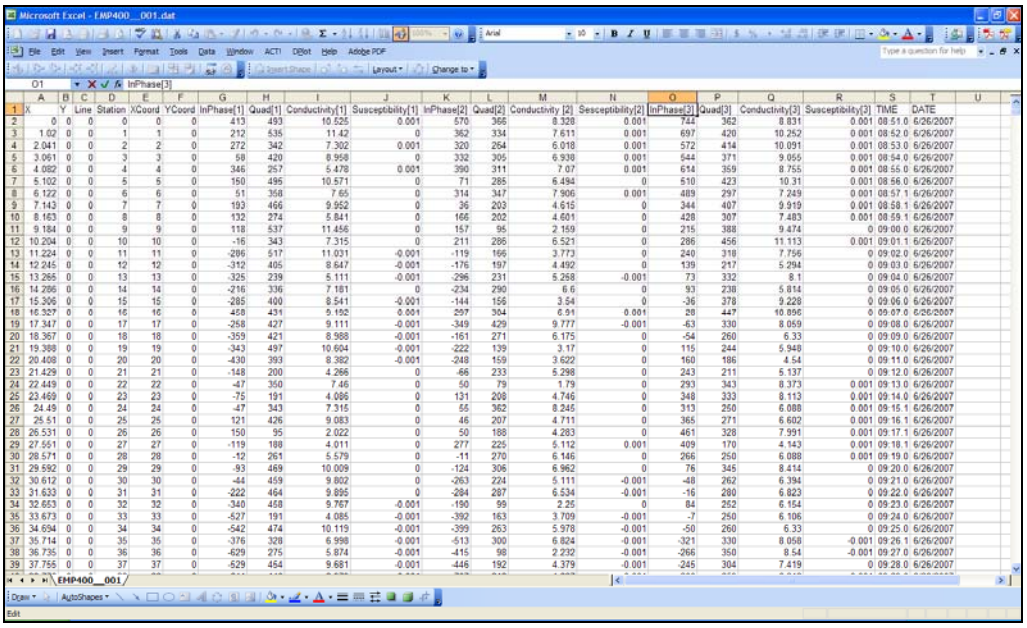


Figure 92: EMP400 *.EMI File converted to a Surfer *.DAT file.

4.5: Working with *.EMI and GPS Files in MagMap2000

The EMP-400 incorporates an integrated 12-channel WAAS GPS receiver for collecting geo-referenced EM data and can be easily configured with an external GPS or DGPS system via the PDA RS-232 interface.

When data is collected with the GPS enabled, the EMP-400 will create an EMP400___00#.GPS file for each data file collected. This file is required by MagMap2000 to integrate GPS and EM data. It is formatted as a standard NMEA GGA string. In addition, the EMP-400 will store the GPS data ***in*** the *.EMI file in Decimal Degrees format. This allows the user to bypass the MagMap2000 program and its associated GPS smoothing and editing functions, if desired.

1. To begin working with your EMP400.EMI and GPS files, open MagMap2000.
2. Select File and open your EMP400.EMI file. If the GPS was enabled during data collection, the MagMap2000 program will 'look' for an EMP400___00#.GPS file in the same folder location as the EMP400.EMI file.
3. To open an EMP400.EMI file, select the File Open tab from the Main menu. Using the Look In Directory search bar, select the directory to which you transferred your EMP400.EMI files.
4. Upon first opening the program, the user may have to select the **Files of Type** box in the file open dialog box and select the GSSI Profiler (*.EMI) file type before the system will recognize the EMP400.EMI files.
5. Once you have selected the file you wish to process, the MagMap2000 program will open the GSSI Profiler Information display. This is information comprises data stored in the file header (Figure 93).

- If the check box "Use GPS to Load the Data" is checked, the program will load the data with GGA GPS coordinates in the associated EMP400___00#.GPS file and convert then to Decimal Degrees.
- If the check box "Use GPS to Load Data" is checked and the *.GPS file is **not** in the same location (directory\folder) as the EMP400.EMI file, MagMap2000 will issue a warning, "Warning! GPS Status is enabled but no GPS file is available." The operator may also receive this warning if the EMI or GPS file is corrupted in any way.
- If the check box "Use GPS to Load data" is left unchecked, MagMap2000 will use the grid parameter information stored in the file header (Figure 93) to grid the data.

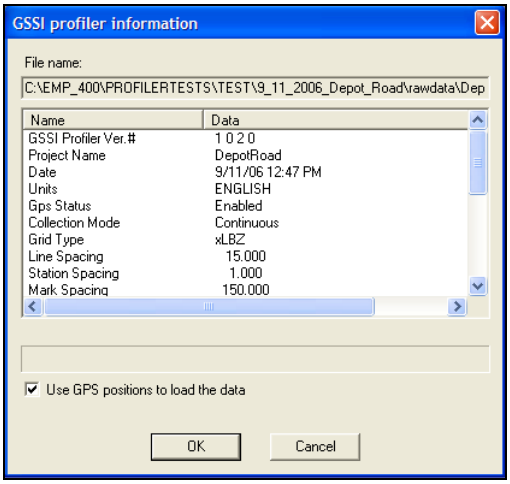


Figure 93: File Open dialogue box.

6. After selecting "Use GPS positions to load the data," MagMap 2000 will display the data in Decimal Degrees format (Figure 94). The green squares indicate the start coordinate of a survey line, and the **red** squares indicate the end coordinate of a survey line. The blue squares indicate reading locations and the **black** arrows superimposed on the blue squares indicate the direction in which the transects were acquired.

Note: In some cases during the course of an EM survey using GPS, the GPS system may "drop" a fix. In the case of a system receiving a DGPS correction signal, in some cases, the GPS system may lose signal lock or the update period for the DGPS correction signal may be exceeded. In these instances, MagMap 2000 will log the last correct position data, and "drop" the fix at the location at which the DGPS correction signal was lost. MagMap 2000 will not plot a fixed position ???????

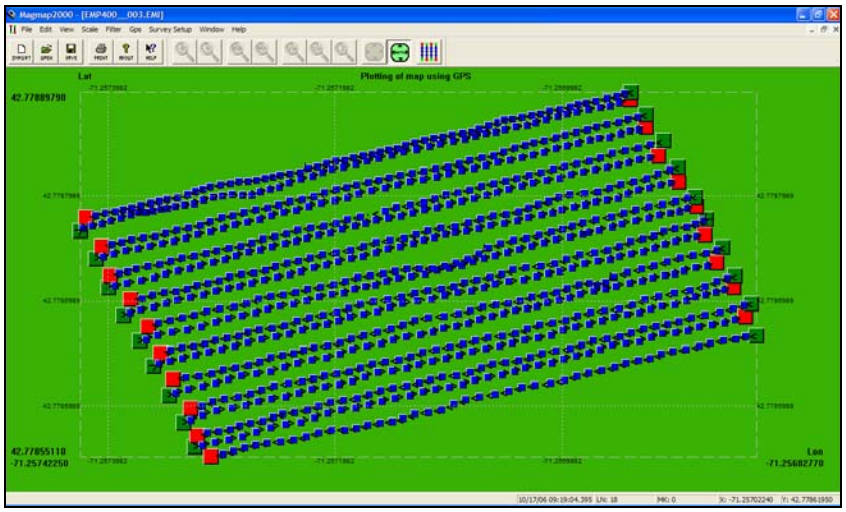


Figure 94: EM\GPS plotted data.

Converting Decimal Degree Geographic Coordinates to UTM

There are several functions available for smoothing/transforming the EM/GPS data in MagMap2000.

1. The first function is the UTM transformation (**U**niversal **T**ransverse **M**ercator). This function will transform the GPS decimal degrees geographical coordinates to UTM coordinates. Select GPS for the MagMap2000 toolbar, and then select **UTM Setup** (Figure 95).

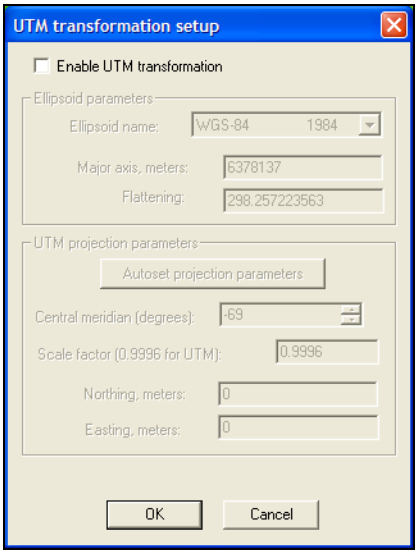


Figure 95: UTM Setup dialog box.

2. To convert to UTM coordinates, select the **Enable UTM transformation** box (Figure 96).

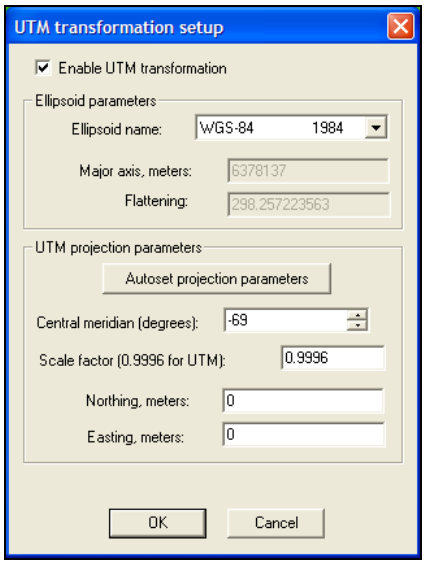


Figure 96: UTM Setup dialog box.

- **Enable UTM Transformation:** This function allows you to turn the UTM transformation on or off. When it is turned off, MagMap2000 will use geographical coordinates. MagMap2000 will use the given parameters to calculate UTM parameters when it is selected.
- **Ellipsoid Name:** This is the type of ellipsoid used to approximate the shape of the earth. Since the Earth is not a perfect sphere, some ellipsoids may be closer approximations to the region where you have conducted your survey than others. The "standard" ellipsoid is the WGS-84 (World Geodetic System).
- **Autoset Projection Parameters**: This function is useful when you do not know what the prime Meridian you are using is, or when your data lies in an area where your prime meridian may change.
- **Prime (Central) Meridian**: If you have not selected "Autoset projection parameters", you must fill this value in. This value has a large affect on the UTM coordinates generated due to the non-uniformity of a particular ellipsoid. It can be quickly estimated as the value of the longitude but you should look it up. The UTM system uses zone code instead of specific projections. Each zone has a central meridian. Zone 14, for example, has a central meridian of 99 degrees west longitude. The zone extends from 96 to 102 degrees west longitude. The table below (adapted from the MagMap 2000 User Guide 24891-01 Rev G) lists the UTM zone code as used in the GCTPc projection transformation package.

Zone	C.M.	Range	Zone	C.M	Range
01	177W	180W-174W	31	003E	00E-006E
02	171W	174W-168W	32	009E	006E-012E
03	165W	168W-162W	33	015E	0012E-018E
04	159W	162W-156W	34	021E	018E-024E
05	153W	156W-150W	35	027E	024E-030E
06	147W	150W-144W	36	033E	030E-036E
07	141W	144W-138W	37	039E	036E-042E
08	135W	138W-132W	38	045E	042E-048E
09	129W	132W-126W	39	051E	048E-054E
10	123W	126W-120W	40	057E	054E-060E
11	117W	120W-114W	41	063E	060E-066E
12	111W	114W-108W	42	069E	066E-072E
13	105W	108W-102W	43	075E	072E-078E
14	099W	102W-096W	44	081E	078E-084E
15	093W	096W-090W	45	087E	084E-090E
16	087W	090W-084W	46	093E	090E-096E
17	081W	084W-078W	47	099E	096E-102E
18	075W	078W-072W	48	105E	102E-108E
19	069W	072W-066W	49	111E	108E-114E
20	063W	066W-060W	50	117E	114E-120E
21	057W	060W-054W	51	123E	120E-126E
22	051W	054W-048W	52	129E	126E-132E
23	045W	048W-042W	53	135E	132E-138E
24	039W	042W-036W	54	141E	138E-144E
25	033W	036W-030W	55	147E	144E-150E
26	027W	030W-024W	56	153E	150E-156E
27	021W	024W-018W	57	159E	156E-162E
28	015W	018W-012W	58	165E	162E-168E
29	009W	012W-006W	59	171E	168E-174E
30	003W	006W-000E	60	177E	174E-180W

- **Northing/Easting**: These are constant values that you (usually) add to your UTM coordinates. UTM Coordinates are usually large numbers of approximately a million meters; however, your survey may be on the order of tens, hundreds or thousands of meters. This allows you to simplify your final numbers by adding or subtracting the large offset values.

In most cases it is advisable to let the program automatically set the UTM parameters since an incorrect value for the prime meridian can seriously affect how your data will appear on the display.

3. If you are satisfied with the UTM conversion settings, select **OK**. Figure 97 illustrates the data set converted to UTM coordinates.

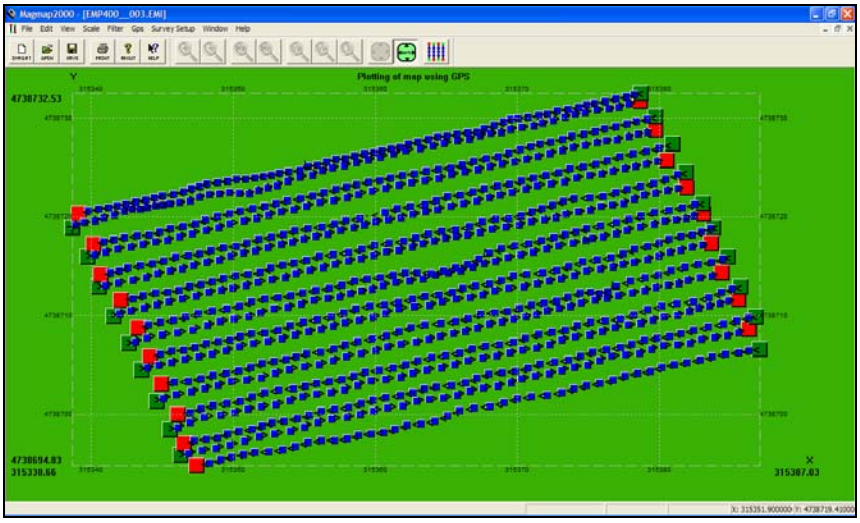


Figure 97: Decimal Degree data converted to UTM coordinates.

Smoothing GPS Positions

The MagMap2000 GPS Smooth Position allows you to smooth your GPS data and eliminates spikes in your GPS position data. MagMap2000 uses a smoothing spline of the third degree to smooth GPS data. We start with the GPS Position screen illustrated in Figure 98.

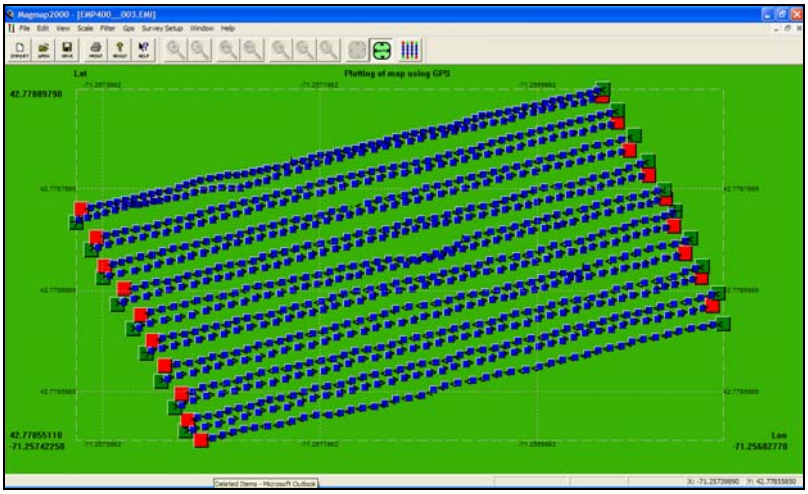


Figure 98: GPS Position display.

1. After selecting the GPS menu option > Smooth positions, select the GPS Smooth Position option from the Main menu and the Line Smoothing Parameters Setup window will be displayed (Figure 99).

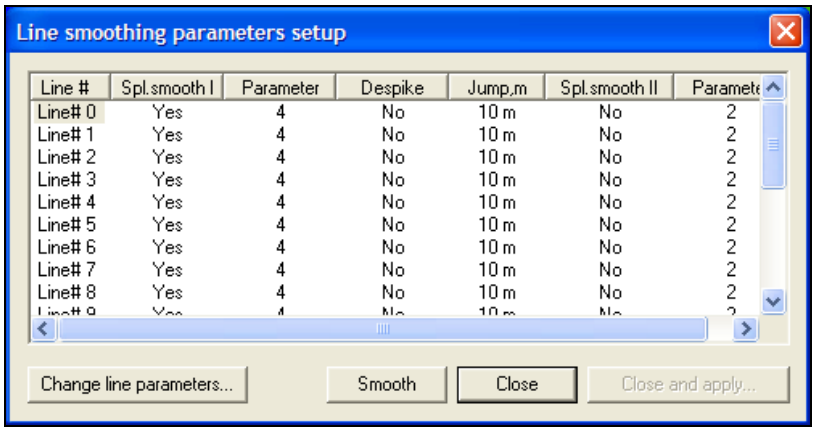

Line smoothing parameters setup
Line # | Spl.smooth I | Parameter | Despike | Jump,m | Spl.smooth II | Paramete
Line# 0 | Yes | 4 | No | 10 m | No | 2
Line# 1 | Yes | 4 | No | 10 m | No | 2
Line# 2 | Yes | 4 | No | 10 m | No | 2
Line# 3 | Yes | 4 | No | 10 m | No | 2
Line# 4 | Yes | 4 | No | 10 m | No | 2
Line# 5 | Yes | 4 | No | 10 m | No | 2
Line# 6 | Yes | 4 | No | 10 m | No | 2
Line# 7 | Yes | 4 | No | 10 m | No | 2
Line# 8 | Yes | 4 | No | 10 m | No | 2
Change line parameters...
Smooth
Close
Close and apply...

Figure 99: GPS Line Smoothing Parameters dialog box.

This dialog box lists all of the lines in your survey (in this example 19). You will also see a series of parameters that can be set to manipulate the magnitude and type of smoothing. This dialog box allows you to set the smoothing parameters for each line. You can select any of the parameters, except Line#, and modify the value. The parameters are:

Line #: This is the number of the line you wish to smooth.

Spl. Smooth 1: This allows you to turn the smoothing on or off for any given line.

Parameter: This controls the degree of smoothing applied to the selected line. The higher the value, the greater the degree of smoothing.

Despike: This allows you to select whether you would like to despike before smoothing.

Jump: This controls the distance that is considered a "spike." The smoothing algorithm will calculate a smoothing curve. It will then calculate the distance between the smoothed points and your original points. If any of these distances are greater than the distance you specified in "jump," the point will be replaced by a point on the smoothed curve. All points falling within the "jump" distance of the smoothed curve will be smoothed. All points falling outside the "jump" distance of the smoothed curve will be left untouched.

Note: It is recommended that the operator perform a second smoothing after using the "jump" function to despike the curve since the curve is not actually smoothed. The first smoothing spline is used only for calculating if a given point is a spike. If you perform smoothing a second time, the program will smooth the despiked data.

Spl. Smooth II: This enables you to turn on a higher degree of smoothing. This will be performed after your first despiking and smoothing have been performed.

Parameter: This controls the degree of smoothing for the second pass smoothing; the higher the value, the greater the degree of smoothing.

The user can also change the parameters for an individual line by selecting the line number and then selecting Change Line Parameters. This is illustrated in Figure 100 for Line # 0.

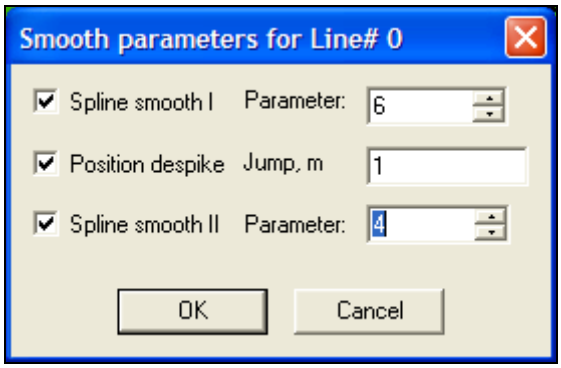


Figure 100: Smooth Line Parameters (Line #0).

In this example, we have changed the first smoothing parameter from four (the default value) to six for a higher degree of smoothing. We have also increased the second smoothing parameter to four (default value of two). We have also included a position despike with a jump of one meter. After selecting **OK** these changes are reflected in the Line smoothing parameters setup dialog box.

2. To perform the smoothing, select **Smooth**. If all lines were selected for smoothing, a series of yellow lines will be displayed that indicate what your smoothed data will look like if you apply the changes.

Note: No changes are applied to the data until you select **Close > Apply**. If the results of the smoothing operation are unacceptable, you can exit the screen by selecting **Close**, or you can change the smoothing parameters and select **Smooth** again.

Figure 101: GPS locations as they appear (in blue) and after smoothing and despiking (yellow lines).

An inspection of Figure 101 shows that some lines are straighter than others. In this example, some transects required the operator to walk around obstacles during data collection. However, all lines have had the same degree of smoothing applied.

We could smooth out Line 0 and 1 (top of the map) and Lines 8 and 9 (middle of the map) by applying another pass of smoothing with a higher smoothing parameter. Once the user has selected **Close > Apply**, the changes to the GPS positions are permanently applied and cannot be

undone. To undo changes to the GPS positions, you would have to reload the original file and re-smooth the data.

The smoothed data is illustrated in Figure 102 .

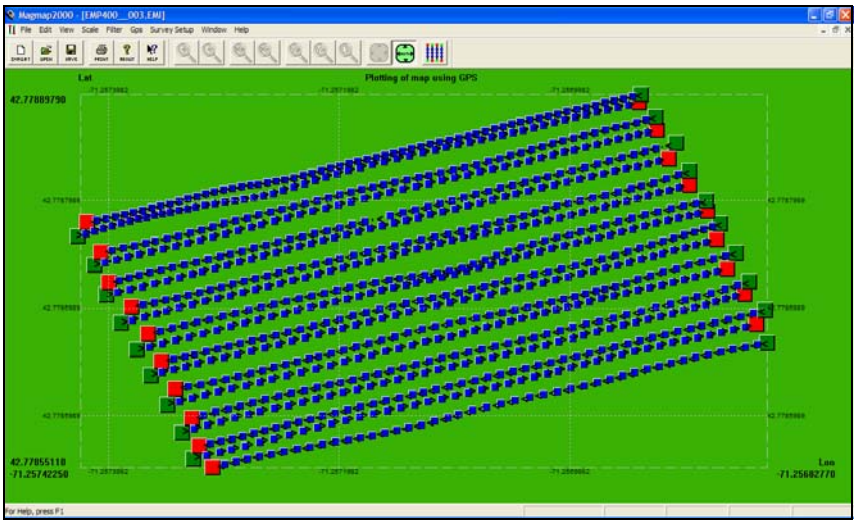


Figure 102: GPS locations, as they appear after 1 pass smoothing and despiking.

For other tips on smoothing procedures and warnings about smoothing, we refer the user to Section 8.5.1 of the MagMap 2000 User Guide.

Appendix A: Understanding GPS And WAAS

GPS - What is it?

WAAS GPS is a navigation system designed to provide instantaneous position, velocity and time information almost anywhere on the globe at any time, and in any weather. It typically provides positioning accuracies of approximately 3 meters. Since GPS receivers need to see much of the sky, it works poorly indoors, in the woods and in urban and semi-urban areas where nearby buildings create GPS signal multi-path problems.

Why do I need it?

You probably don't. In fact, for many EM applications you can just use a measuring tape and stakes or spray paint to measure and mark out your grid and take notes about your site an transect start and stop locations. Since post-survey verification digging or drilling often requires more precision than 3 meters, knowing approximately where you are is not helpful. However, as surveys become larger and as technologies improve, WAAS GPS can be very helpful in telling you where you are on a map, or what road you turned onto, or what section of the site you have already covered. Increasingly WAAS GPS is claiming a legitimate place in the ever-increasing size and variety of geophysical applications.

How does it work?

Standard GPS works by three-dimensional trilateration of the distance from a constellation of GPS satellites in space. The satellites measure the time is takes a GPS satellite signal to travel from one point to another very accurately and then estimate the distance based on the travel-time of the signal using the speed of light as the signal velocity. Getting the travel-time calculations from just three satellites is enough to know where you approximately are on the earth. Four or more satellites are required for higher accuracy. Getting the travel-time from 6 or more satellites greatly decreases the uncertainty of your position. Typically, around buildings and trees you might "see" six satellites, plenty to know where you are to within 3 meters. The degree of precision depends on many things like how well distributed the satellites are in the sky or the precise travel path the signal takes to get from the GPS satellites to your GPS receiver.

Main sources of error

The GPS signal travel-times and paths are directly affected by the medium through which the signals are transmitted. For GPS, this means the signal from the satellites to your receiver can be slowed down and bent by changes in the Ionosphere, the Troposphere and nearby objects. These sources of error are illustrated in Figure 3.16 . These sources of error can be reduced using expensive tricks like dual frequency systems, Klobuchar modeling, and Real Time Kinematic (RTK) solutions. The least expensive way to correct for these errors is through Differential GPS (DGPS), where data from a second stationary base station GPS is subtracted from a roving GPS or in the form of a differential GPS signal coming from a GPS satellite or ground beacon. Such differential signals are provide at extra cost through subscription services such as OMNISTAR or THALES. Compared to the distance from the satellite, the distance between a base station and rover is insignificant, which means that the travel paths through the ionosphere and troposphere

are (essentially) identical. The difference between the two positions subtracts out atmospheric effects, leaving just the rover position.

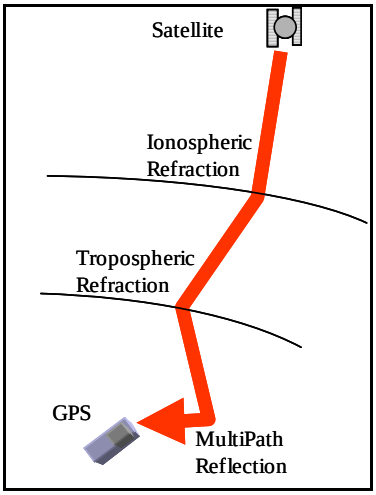


Figure 103: Main Sources of GPS Error.

What is WAAS?

The **W**ide **A**rea **A**ugmentation **S**ystem (WAAS) is a form of differential GPS that uses geostationary GPS satellites to transmit an error correction estimate back down to your GPS receiver. The measured positions of ground reference stations, strategically positioned across the country, are transmitted up to the WAAS satellites. Your receiver reads the signal from the WAAS reference station closest to you. It uses a combination of specialized WAAS satellites and ground-based stations to send correction signals to WAAS GPS receivers, as well as providing integrity information for each satellite's signal and is equivalent or better than RAIM (Receiver Autonomous Integrity Monitoring), thereby improving the accuracy of the standard GPS signal by approximately 5 times.

The European Geostationary Navigation Overlay System (EGNOS) is the European equivalent to this United States system. In Asia, it's the Japanese Multi-Functional Satellite Augmentation System (MSAS). The International Civil Aviation Organization (ICAO) calls this type of system a Satellite Based Augmentation System (SBAS). A typical WAAS system is illustrated in Figure 104

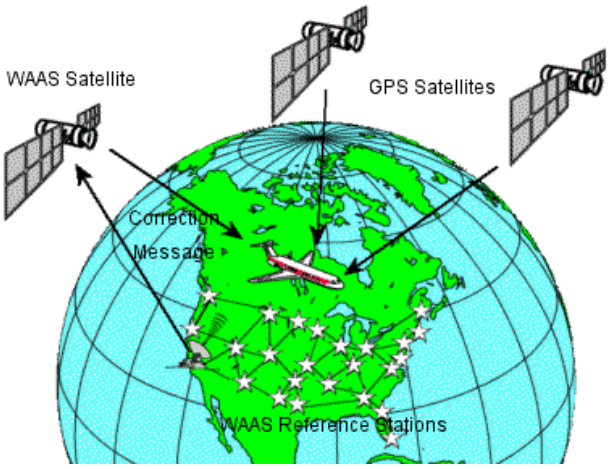


Figure 104: GPS Satellites and WAAS Satellite and reference stations.

WAAS testing in September 2002 confirmed accuracy performance of 1 – 2 meters horizontal and 2 –3 meters vertical throughout the majority of the continental U.S. and portions of Alaska. (SEE: http://gps.faa.gov/Programs/WAAS/waas.htm).

What is NMEA?

The **N**ational **M**arine **E**lectronics **A**ssociation (NEMA) has generated a standard set of messages for communicating GPS information. The EMP-400 uses the NMEA 0183 version 2.1 protocols. The EMP-400 WAAS GPS receiver has been configured to send a **GGA** data or message string and the PDA will accept **only** a GGA message string. No other NMEA strings are supported for the Profiler by GSSI.

Appendix B: Example of GGA Data String

STRING: $GPGGA,hhmmss.ss,llll.ll,a,yyyyy.yy,a,x,xx,x.x,x.x,M,x.x,M,x.x,xxxx*hh

GGA = Global Positioning System Fix Data

1 = UTC of Position
2 = Latitude
3 = N or S
4 = Longitude
5 = E or W
6 = GPS quality indicator (0=invalid; 1=GPS fix; 2=Diff. GPS fix)
7 = Number of satellites in use [not those in view]
8 = Horizontal dilution of position
9 = Antenna altitude above/below mean sea level (geoid)
10 = Meters (Antenna height unit)
11 = Geoidal separation (Diff. between WGS-84 earth ellipsoid and mean sea level. -=geoid is below WGS-84 ellipsoid)
12 = Meters (Units of geoidal separation)
13 = Age in seconds since last update from diff. reference station
14 = Diff. reference station ID#

Appendix C: Conducting a Survey

Prior to conducting any survey, the user should evaluate the objective(s) of the investigation and the survey site conditions. The survey objective should be carefully considered, as this will determine the frequency(ies) of operation, the mode(s) of instrument operation and the spatial sampling density required. The local surficial geology should be investigated in detail, as the on-site geologic conditions will be a principal factor in determining the effectiveness of the induction method. Site conditions such as topography, the presence and proximity of surface cultural features and surface vegetation should all be evaluated. These will affect survey logistics, data quality, and ultimately the survey results.

C.1 Survey Planning

Survey planning can be broken down into two phases. The first phase involves collecting information on the site geology, hydrogeology, and the site history, as well as evaluating the physical conditions at the site and its suitability for conducting an EM survey. Any site conditions which may present obstacles to the efficient collection of high quality data must be taken into consideration, or dealt with directly prior to moving on to the second phase, survey grid setup.

EM surveys often have multiple objectives. These may include the detection of buried objects such as metallic tanks, drums or buried foundations, the detection and delineation of waste burial pits or trenches, the mapping of the surficial soils and/or overburden materials, the detection and delineation of contamination plumes in the soil and groundwater or mapping the location and extent of geologic or archaeological features.

If there are multiple survey objectives, it is generally desirable and more cost effective to plan the survey coverage so that it will be effective in addressing the most difficult of the survey objectives. The required level of survey coverage that will provide adequate information to meet the most difficult survey objective will generally be more than sufficient to meet the requirements of other secondary goals. The frequency(ies) of operation, spatial sampling density, the mode of operation (i.e., the instrument geometry) and, in some cases, the speed at which the data is collected, determine the level of survey coverage and measurement precision.

As we have indicated above, the first phase in survey planning is to acquire as much information as possible on the geologic and hydrogeologic conditions of the site. This information should be collected from as many sources as possible. These sources could include maps of the surficial geology of the area (surficial geology maps of most areas of the US are available from the USGS), as well as data from local or on-site well logs, test borings and/or test pits. It is also extremely useful to obtain any available reports of previous geologic or geophysical investigations that may have been conducted at the site. Publications on the application of EM for similar types of surveys should be carefully reviewed. These studies can provide valuable insight on data collection methods, data processing and data interpretation.

In urban and semi-urban areas, collecting data on the land-use history of the site (if possible) is also extremely important.

The review of all available geologic information enables the survey planner to assess the on-site geologic conditions and their possible affects on the overall effectiveness of the method, to make

estimates of the magnitude of the conductivity contrasts that may be encountered and to make estimates of measurement sensitivity and probable depths of exploration (DOE).

The land-use history data can provide the survey planner with information on the approximate location and distribution of extant or historical man-made features. When evaluated within the context of the primary survey objective, this information is of primary importance in any planning decisions regarding survey grid location, orientation, and transect spacing.

The topographic variations at the site should also be evaluated during the survey planning stages. Significant topographic variation in some geologic settings can have an effect on subsurface induction readings. The possible impact of topographic variations on the data should be evaluated to determine their possible effects on the measurements. If deemed necessary, topographic data should be collected. The contoured topography data can then be compared to the induction measurements to ascertain if there is any relationship between topographic variation and the measured subsurface conductivity variations.

The presence and distribution of man-made cultural artifacts on the surface should also be evaluated. The presence and location of electrical conductors (e.g., fences, cars, metallic light posts, etc) and large structures on the surface will have an adverse effect on the quality of EM data. In some cases, it may be necessary to modify survey coverage to avoid the influence of these features. It the survey site has areas of significant vegetation, or is completely covered by vegetation, it should be cut and removed prior to grid layout and data collection to assure that it does not present an obstacle to the operator during the process of data collection. Ideally, the site should be cleared to the extent that surface growth would not present an obstacle to the operator and the instrument during the continuous collection of data. This assures that an operator can maintain a steady, constant walking pace during data collection and maintain steady orientation of the instrument.

C.2 Survey Grid Setup

Once all available information regarding the site has been collected and evaluated, the investigator can proceed to the survey grid setup. Survey grid setup requires the following tools:

- Survey Tapes – preferably three double-sided tapes with English units on one side and Metric Units on the other.
- Plastic survey flags.
- Wooden survey stakes.
- Mallet for driving stakes.
- Rolls of plastic fluorescent flagging tape.
- Marking paint, chalk or lumber crayons.
- A permanent marker for marking survey stations on survey stakes or flags.
- A field notebook for logging notes on surface features, topography and surface conditions.
- A quality compass, preferably a survey grade instrument.

- A set of ropes with distance intervals marked on them with colored tape, flagging or knots. These ropes are very useful, as they allow the investigator to follow a straight, distance-indexed line along each survey transect. It is useful to have two, as they can be leapfrogged from one transect to the next as the survey progresses. The distance intervals marked are generally 5, 10 or 20 feet for a survey conducted in English units and 1, 5 and 10 meters in metric units. The marked distance interval required for a particular survey will be determined by the survey objective and the required level of survey detail and survey control.

It is standard field practice to lay out an orthogonal grid of survey lines. These lines must be laid out so that they provide the required level of survey coverage to meet the objective(s) of the survey i.e. the objective(s) that require the highest spatial resolution. During the course of survey layout, it is a standard and highly recommended practice to create a map of the survey grid with specific grid locations referenced to permanent or semi-permanent surface features. The investigator should update this map, along with the survey notes if any of the data acquisition or survey grid parameters are changed during the survey.

In many cases, the origin is a pre-surveyed point or benchmark, or a GPS geo-referenced location. In the absence of a pre-existing survey origin, the investigator will have to select a relative survey origin point. This point may be the corner of a lot, a building, or some other permanent surface feature. The investigator must act as surveyor and lay out two orthogonal baselines. Standard surveying practice is to define the direction of the baseline relative to geographic north and east. Often the requirements of survey coverage and site conditions require that the baseline direction be something other than a cardinal point (i.e. due north or due east). Standard mapping convention is to orient north to the top on the site map and east to the right on the site map. The baseline is designated north if its compass bearing is more than 45° north-northeast i.e. the baseline is aligned more in a north-south than east-west direction. Otherwise, the baseline direction is defined as east. The easiest way to lay out an orthogonal grid is to use the right triangle method. This assures that the baseline and transect lines are at right angles to each other and that the survey grid is square. This is achieved by laying out two survey tapes to a distance that is approximately 25-50% of the actual survey gird size at approximately right angles to each other. Using the familiar Pythagorean Theorem; $\boldsymbol{A}^2 + \boldsymbol{B}^2 = \boldsymbol{C}^2$**,** one can quickly and easily lay out orthogonal baselines. An example for performing this is illustrated in Figure 105.

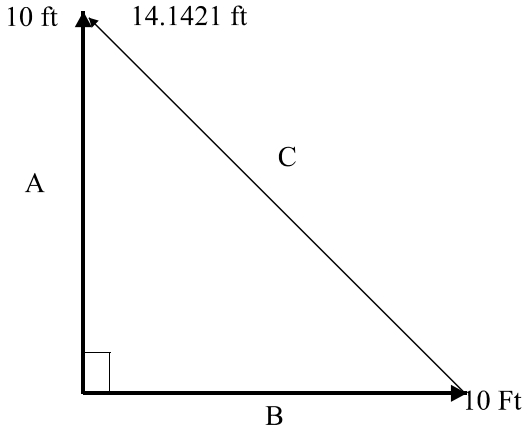


Figure 105: Right triangle method for establishing and orthogonal survey grid baseline. Leg A = 10 ft. Leg B = 10 ft. Leg C (the Hypotenuse) = 14.1421 ft.

Given the relationship $A^2 + B^2 = C^2$ and that the Leg A =10 ft and the Leg B = 10 ft, we can see that $A^2 + B^2 = 200$. Taking the square root of C = $\sqrt{200}$, we arrive at C = 14.1421 ft. If we place the end of the third tape (C) at the 10 ft mark of B and the 14.1421 ft mark of tape (C) at the 10 ft mark of A, we will have a right triangle and the baseline will be square. The transect lines for the survey can now be marked off at regular intervals. Site conditions and line lengths may necessitate the laying out of several of these "corners," particularly on large open survey sites, to assure that the entire grid is square, that the survey lines are parallel and that the line spacing is consistent at the beginning and end of the transects. This method can easily be expanded for larger survey areas by using multiples of 10 for the A and B legs of the triangle and calculating the square root of the sum $A^2 + B^2$.

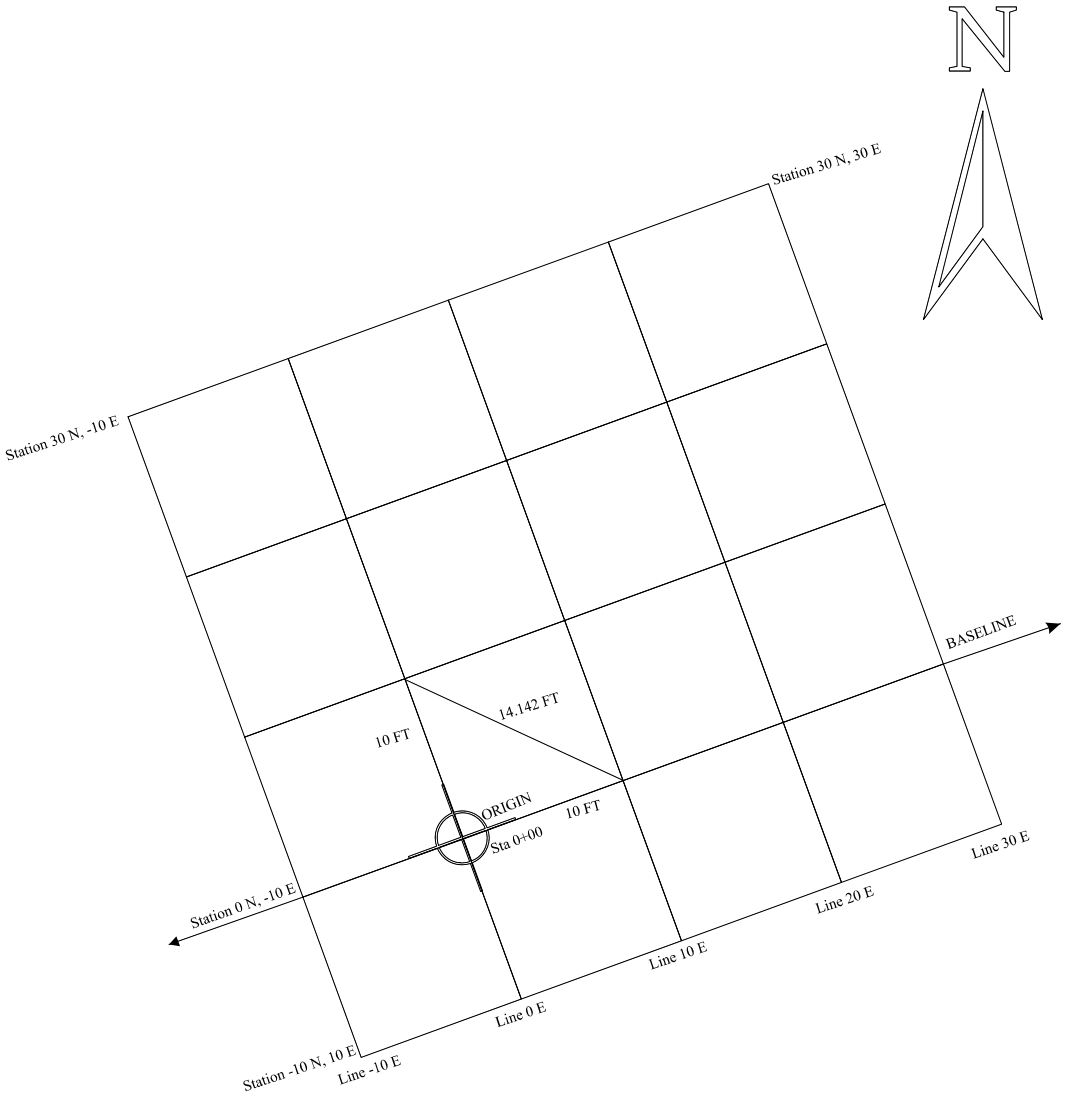


Figure 106: Example section of site plan map.

Figure 106 is an illustration of an example site plan map. This is an example of the line-and-station system used by most investigators in the field. An origin (relative, benchmarked or geo-referenced) is defined for the local co-ordinate system. The distance along the baseline from the survey origin to an orthogonal survey line is (generally) given as the survey line number i.e. a

transect line 20 feet east of the origin would be survey line 20E, a survey line 20 feet west of the origin would be survey line -20E (or 20 W) and so forth. The distance along the survey (or transect) line is the station, or station number. If the baseline is oriented north, then the survey direction is east. In this illustration, the baseline is east and the survey direction is both north and east.

It is best practice to collect data in both directions. The survey grid should be laid out in such a fashion that the survey lines are normal (i.e., perpendicular) to the presumed or visible trend of any feature(s) of interest. Based upon anomalous instrument readings acquired during the course of the survey, supplemental lines that are intermediate to the survey grid lines or oblique i.e., at an angle, to the survey grid, should be acquired to better constrain the location and extent of suspected anomalies.

The use of GPS systems to collect geo-referenced data along with geophysical data has become much more prevalent in recent years and the EMP-400 is equipped with a WAAS (Wide Area Augmentation System) GPS and is compatible with external, high-resolution GPS systems.

In many survey locations, the absence of sufficient satellite coverage and the multi-path interference caused by nearby buildings or other structures may render the use of GPS positioning systems impractical or problematic at best.

The investigator should carefully evaluate the line-of sight conditions at the site and the true position accuracy of the GPS system to be used. The user should always consult a GPS mission planner and a have recent satellite ephemeris and almanac data on the position of visible satellites prior to using a GPS system for geo-referenced survey data. (Note: A free mission planner called QuickPlan and the current ephemeris and updated almanac can be downloaded from Trimble at: www.trimble.com/support_trl.asp?NAV=Collection-3627.)

The positional accuracy of the survey is directly related to the regularity of the line spacing and consistency of the measurement interval along each survey line. This is where survey ropes can prove to be extremely useful. When strung between the endpoints of the survey line, they provide a straight line for the investigator to follow as data is collected. In situations where survey ropes are impractical (e.g., collecting data along very long transects) plastic survey pin-flags, or stationed wooded stakes should be used at 10 to 20 foot intervals, or 5 to 10 meters intervals, to serve as a walking guide for the investigator.

C.3 An Example Survey

Let us assume for the moment that the objective of our survey is to detect and delineate the buried foundation of an old paint factory. Review of geologic and hydrogeologic data indicate that the surficial geology of the area was originally part of an outwash plain characterized by buried stream channels, gravel deposits and course to fine grain inter-bedded sand and silt. Historical records indicate that the site has seen significant modification and that most of the native subsurface materials have been re-distributed, removed and/or replaced by heterogeneous fill materials of variable composition. Review of available records indicates that masses of buried paint cans have been buried in shallow (< 4 ft deep) trenches, or as individual groups of cans scattered about the site. These are suspect as being the point sources for groundwater pollution detected in on-site monitoring wells. In this case, the detection of small, metallic targets buried at moderate to shallow depths would present the most difficult of the survey

objectives. Given the site geologic conditions, small metallic targets will only be detectable at relatively shallow depths and at small lateral distances from the instrument.

To meet the survey objective, we would like to have the transects a short distance apart, approximately 1 meter. Ideally we would like to operate the instrument in close proximity to the surface; approximately 10-20 cm. As no hard data is available to us on the actual depth of burial of the targets, we must assume that they are buried at or near the maximum depth of investigation range of the instrument.

As the geologic and land-use data indicate that the subsurface materials are generally resistive, the frequency(ies) of operation should be selected such that the response from the depth range of interest is maximized. Given a site with these conditions, a general rule of thumb would be to conduct preliminary test transects in the mid to upper frequency range of instrument, i.e., from 9 to 16 kHz. As system response and depth of exploration are a function of both subsurface conductivity and the frequency(ies) of operation, it is advisable that the user conduct test transects at several frequencies prior to commencing the survey.

The system can be operated in either the in-line orientation, with the instrument transmitter and receiver aligned and parallel with the survey transect, or the broadside orientation with the instrument transmitter and receiver on two parallel traverse lines and the line between the transmitter and receiver aligned perpendicular to the transect direction.

Each method has its advantages and disadvantages. Under certain field conditions, collecting data with the in-line method affords the operator somewhat greater control over unwanted movement of the coils during data collection. Using the broadside method, controlling the orientation of the instrument can prove more difficult, as the instrument may tend to swing from side to side as the operator walks along the survey transect. This type of coil motion can have adverse affects on the quality of the data.

In areas of significant surface vegetation, in-line operation is advantageous, as the instrument presents a smaller cross-section to surface obstructions such as high grass, brush, bushes, and trees. Operation in the in-line orientation may be desirable in locations where the operator has a priori information regarding the trend of linear conductive targets, such as large metallic utilities, the orientation of buried foundation walls, or the strike of a geologic feature, such as a conductive dike. In-line survey transects can then be collected perpendicular to the trend (strike) of the target, reducing possible asymmetries in the target response.

As the transmitter and receiver are on separate transects, data collected along a survey transect in the broadside orientation will cover a larger area than a traverse collected in the in-line orientation for an instrument with fixed coil spacing. Operation in the broadside orientation will also (generally) produce narrower, tighter anomalies, and therefore better spatial resolution than operation in the in-line orientation. This is because standard data-point plotting convention for moving source methods is to plot each measurement at the midpoint between the transmitter and receiver. Given a conductive target of limited dimension and two traverses collected over the target, one in the in-line orientation and the other in the broadside orientation, the number of survey data points along the transect at which the instrument will register a response is much smaller for the broadside orientation than the in-line orientation. The instrument response for an in-line transect over such a target will be stretched out along the line of the transect in comparison to the response from an equivalent broadside transect.

Appendix D: Useful References

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